CLINICAL CONGRESS OF AMERICAN COLLEGE OF SURGEONS
Ninth Annual Session, New York, October 20-24, 1919

ANNUAL SUBSCRIPTION: UNITED STATES AND CANADA, $10.00; FOREIGN, $12.00

Volume XXIX SEPTEMBER, 1919 Number 3

GENERAL LIBRARY
SEP 10 1919
UNIV. OF MICH.

Surgery, Gynecology and Obstetrics

WITH

International Abstract of Surgery

EDITORIAL STAFF

FOR AMERICA

William J. Mayo, M.D.
E. Wyllys Andrews, M.D. J. Clarence Webster, M.D.
L. L. McArthur, M.D. E. C. Dudley, M.D. Frederic A. Besley, M.D.
A. J. Ochsner, M.D. C. S. Bacon, M.D. Carl Beck, M.D.
Thomas J. Watkins, M.D. John L. Porter, M.D. William R. Cubbins, M.D.

FOR THE BRITISH EMPIRE

Sir Arthur Mayo-Robson, C.B., C.V.O., D.Sc., F.R.C.S.
Sir Berkeley Moynihan, C.B., M.S., F.R.C.S. Thomas W. Eden, M.D., F.R.C.S.
Sir Harold J. Stiles, M.B., F.R.C.S. (Edin.) Henry Jellett, M.D., F.R.C.P.I.
James Rutherford Morison, M.B., F.R.C.S.

Franklin H. Martin, M.D., Managing Editor
Allen B. Kanavel, M.D., Associate Editor

EDITORIAL AND BUSINESS OFFICES: 30 N. Michigan Ave., Chicago, Illinois, U. S. A.
PUBLISHERS FOR GREAT BRITAIN: Bailliere, Tindall & Cox, 8 Henrietta St., Covent Garden, London, W. C., England

JUST OUT

Albee's Orthopedic and Reconstruction Surgery

SAUNDERS, *Publishers* SEE PAGE 13

Entered as second-class matter May 22, 1913, at the postoffice at Chicago, Ill., under the Act of Congress, March 3, 1897.
Published monthly. Copyright, 1919, by The Surgical Publishing Company of Chicago.

"Startling X-Ray News"

The greatest change in new types of apparatus, new methods, etc., since the X-Ray was discovered will appear within the next six months. These universal changes will practically revolutionize the entire industry.

PARAGON X-RAY PLATES

We expect to issue bulletins monthly, reporting these changes, which will be sent free to those interested. If you are now using X-Ray or or intend to purchase an apparatus, *get your name on the mailing list* to receive these free bulletins.

Advise when writing what type of apparatus you now have, if any.

Long experience has enabled Geo. W. Brady & Co. to produce and maintain an unexcelled standard in X-Ray Plates. The Paragon Plate is the result of an effort to give perfect satisfaction. The Universal Plate is recommended as a combination of good service and economy. Both brands are adapted for use with or without intensifying screen.

Partial list of other supplies carried

Barium Sulphate for Stomach Work
Dental X-Ray Films and Mounts
Developing Tanks
Developer Chemicals
Intensifying Screens
Coolidge Tubes

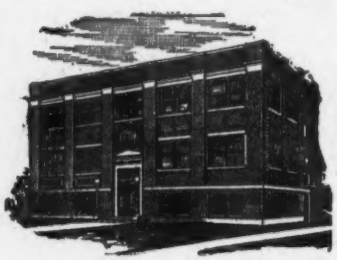
X-Ray Protective Materials

GEO. W. BRADY & CO.

756 S. Western Avenue ***Chicago***

SAVE TWO-THIRDS

Sherman's Bacterial Vaccines, when administered early, will reduce the average course of acute infections like Pneumonia, Broncho-pneumonia, Sepsis, Erysipelas, Mastoiditis, Rheumatic Fever, Colds, Bronchitis, etc., **to less than one-third their usual mortality and duration.**



Sherman's Bacterial Vaccines are prepared in our specially constructed Laboratories, devoted exclusively to the manufacture of these preparations and are marketed in standardized suspensions.

Write for literature.

MANUFACTURER OF BACTERIAL VACCINES

G. H. SHERMAN, M.D.
Detroit, Mich. U.S.A.

SURGERY, GYNECOLOGY AND OBSTETRICS

AN INTERNATIONAL MAGAZINE, PUBLISHED MONTHLY

VOLUME XXIX SEPTEMBER, 1919 NUMBER 3

THE TREATMENT OF HOUR-GLASS STOMACH

BY A. J. WALTON, M.B., M.S., F.R.C.S., LONDON, ENGLAND
Assistant Surgeon ,London Hospital

WITH the more general recognition of the importance of clinical symptoms and the routine use of X-rays and opaque meals, the diagnosis of hour-glass stomach has become greatly simplified; the treatment, however, remains far from satisfactory. A perusal of the more recent literature shows that many forms of operation are still being advocated by different surgeons, but, whereas operative interference in simple cases of chronic gastric ulcer is followed by some 90 per cent of cures, the past statistics available show rather less than 70 per cent of cures in cases of hour-glass constriction, and it must be remembered that even these statistics are based on a relatively small series of cases and, therefore, are unreliable. In undertaking any form of operative treatment, the pathology of this condition must be kept clearly in mind. With the exception of a few cases due to carcinoma or dense perigastric adhesions and the possibility of an occasional case of congenital malformation, one may say that every case of hour-glass stomach is dependent upon the presence of a chronic ulcer situated on the lesser curve. The ulcer itself is associated with widespread fibrosis, and it is the contraction of this fibrous tissue which has given rise to the hour-glass deformity, so that, in the majority of cases, there is only a narrow band of stomach tissue situated along the greater curvature which is free from pathological changes. Moreover, it must also be borne in mind that a large proportion of these cases is associated with pyloric obstruction. Whether or not it be true, as Rovsing[1] believes, that the presence of these two ulcers is secondary to visceroptosis, is of no importance for our present consideration; the fact remains that not uncommonly the hour-glass constriction is associated with pyloric obstruction, and the operative technique must be so devised that both conditions are corrected.

There is perhaps no subject in gastric surgery which has led to so much discussion as the treatment of gastric ulcer situated upon the lesser curve, but, as I shall hope to show in a further communication, the evidence is now strongly in favor of excision of the ulcer combined with pyloric occlusion and posterior gastro-enterostomy.

Before any operative treatment is undertaken, stress must be laid upon the importance of examining the whole of the stomach, and attention again directed to the fact that if the hour-glass obstruction be situated near the cardiac end, the pyloric pouch may be so large that the hour-glass constriction is entirely overlooked and an anastomosis between this pouch and duodenum is performed. Such an operation, of course, would fail to overcome the chief difficulty and is therefore doomed to failure, but, even if a correct diagnosis of the condition has been

[1] Rovsing, T. Ann. Surg., Jan. 1, 1913.

made, many of the operations which have been performed in the past are theoretically incorrect, and are in practice unsatisfactory.

The operations may be considered under the following headings:

1. *Digital dilatation.* This operation which was one of the earliest to be performed has now been practically abandoned. It has been clearly shown in this condition and in other cases of fibrous stenosis that a single stretching of scar tissue is certain to be followed not only by a return of the condition, but in many cases by an exacerbation, for, if the dilatation be carried sufficiently far to afford relief, it will be accomplished at the expense of tearing some of the normal or pathological tissue, and thus will be followed by further formation of scar tissue.

2. *Gastroplasty.* Two forms of gastroplasty have been practised. In the first, an operation is performed similar to that of Allingham's pyloroplasty. A horizontal incision is made in the stenosed portion of the stomach and the opening sutured vertically. The second method which was introduced by Kammerer is an application of Finney's pyloroplasty.[1] In this operation, an inverted V-shaped incision is made through the constricted portion and resutured, so that a large opening is left between the cardiac and pyloric portions.

Both these operations have many drawbacks. First, a large portion of the incision is made through scar tissue, and hence a considerable amount of contraction is almost certain to occur. Second, the ulcer is left untouched, and the operation, therefore, suffers from the same objections as the treatment of an uncomplicated chronic ulcer on the lesser curve by simple gastro-enterostomy. These objections are: the failure to eliminate the possibility of hæmorrhage, of perforation, of the persistence of ulceration, and of the supervention of carcinoma. Third, these operative steps do nothing to overcome any pyloric stenosis which may be actually present or may occur at a later date. Paterson[2] has shown that there is either no relief, or a relapse, in 25 per cent of cases so treated, and this is especially so if the ulcer is active.

3. *Gastro-gastrostomy.* This operation which was first advocated by Wolfler can be performed with or without the use of clamps, has but one advantage over the previous operations; the opening is made in a normal portion of the stomach, and hence there is less likelihood of stenosis occurring. It has, however, all the other drawbacks of the operations previously described, no attempt being made to treat the actual ulcer or to overcome the pyloric obstruction. Paterson has also shown that there is no relief, or relapse, in 30 per cent of these cases.

4. *Single gastro-enterostomy.* This operation of necessity has to be performed on the cardiac side of the hour-glass constriction. It is one of the difficulties in dealing with this condition that the cardiac pouch is often very small and the ulcer is adherent to the pancreas; in such cases, it may be difficult or impossible to bring down a sufficient portion of the posterior surface of the stomach to perform a posterior gastro-enterostomy. In such cases, a junction will have to be performed on the anterior surface, but even then the technical details may be fraught with considerable difficulty and although with the modern methods such an anterior junction is not so objectionable as was at one time believed, it still falls below the posterior method in its efficacy. At the same time it will present similar objections to the previous operations, in that no active steps will be taken to cure the ulcer on the lesser curve. Moreover, should there be a pyloric obstruction, further steps will have to be taken, or the hour-glass constriction will progress until the pyloric pouch is isolated.

5. *Double gastro-enterostomy.* This operation was first suggested by Weir and Foote. It is an operation which is now generally

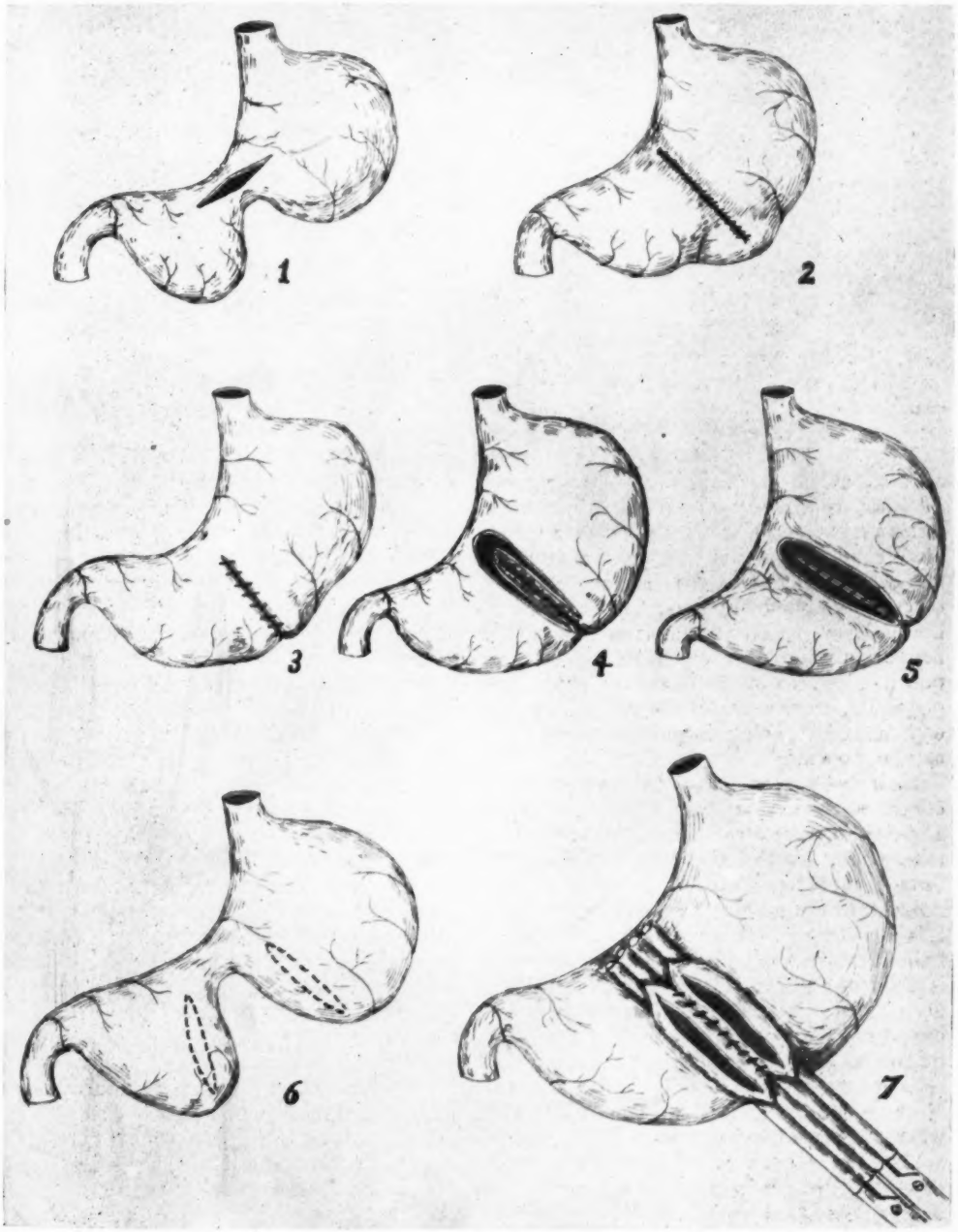
[1] Finney. Bull. Johns Hopkins Hosp., 1902, July.

[2] Paterson, H. J. Practitioner, Lond., 1911, Nov., p. 642.

Figs. 1 and 2. Gastroplasty, Allingham's method. Fig. 1, the position of the horizontal incision. Fig. 2, the horizontal incision sutured vertically.

Figs. 3, 4, and 5. Gastroplasty, Kammerer's application of Finney's pyloroplasty. Fig. 3, the two pouches of the stomach sutured below the isthmus. Fig. 4, method of making the incision. Fig. 5, the posterior edges sutured and the anterior ready to be sutured.

Figs. 6 and 7. Gastrogastrostomy, Wolfler's method. Fig. 6, the position in which the openings are to be made. Fig. 7, method of performing the operation with clamps.



Figs. 1 to 7. (See legend on opposite page).

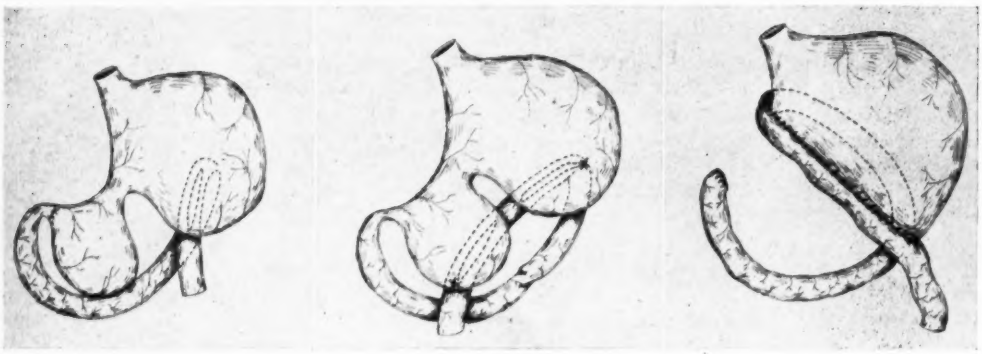


Fig. 8.

Fig. 9.

Fig. 10.

Figs. 8 and 9. Gastro-enterostomy. Fig. 8, single gastro-enterostomy. Fig. 9, double gastro-enterostomy The width of the loop that has to pass through the mesocolon is indicated thus, *x*. . . . *x*.

Fig. 10. Partial gastrectomy. Pyloric portion of stomach excised. Cardiac end implanted into side of jejunum. Polya's method.

regarded as the one of choice. It is advocated by Sherren[1] and by Paterson who gives a series of twelve cases with good results. A loop of the jejunum is taken and a junction made between it and the cardiac pouch as close to the duodenojejunal flexure as possible and a secondary anastomosis made further along the loop with the pyloric pouch. Just as in the case of the single operation, considerable difficulty may be experienced in performing a junction with the cardiac pouch, and it may thus happen that both anastomoses have to be performed on the anterior surface of the stomach. In addition to these drawbacks, there is the fact that a long loop of the jejunum has to be brought up through the mesocolon, which will necessitate the making of a large opening in this structure. As a general rule, it will be found that the available area in the mesocolon is inadequate for this purpose, and that, even at the time of the performance of the operation, undue pressure may be exerted on the middle colic artery. At a later period the contracting opening will tend to kink the jejunum, a danger which will be much greater when there are two junctions. With so large an opening this danger cannot be entirely eliminated, however carefully the mesocolon be sutured to the stomach, and it is of interest to note that one of the cases reported by Paterson developed intestinal obstruction three years after the performance of this operation. As in the previous operations, the actual ulcer is left untouched.

It would seem, therefore, that any operation to be satisfactory must fulfill two requirements. First, it must overcome the mechanical obstruction, whether single or double, or in other words it must efficaciously drain both cardiac and pyloric pouches. Secondly, it must be so devised that it shall lead to a cure of the active ulcer and prevent any complications arising from the presence of such an ulcer. It has been my experience, an experience shared by many surgeons, that posterior gastro-enterostomy is one of the most satisfactory operations when directed toward the treatment of a constricting ulcer situated at the pylorus, but it is insufficient if the ulcer be on the lesser curve, and especially so if it be adherent to the pancreas. In such a case, not only may the ulcer persist and lead to future symptoms after the performance of an anastomosis, but severe and perhaps fatal hæmorrhage or perforation may occur at a later date; and it is now clearly realized that apparent cure of the ulcer may take place after the performance of the anastomosis only to be followed after an interval of a few years by the onset of carcinoma at the site of the ulcer.

These two entirely different requirements can be met by the following methods:

[1] Sherren, J. A System of Surgery. C. C. Choyce, p. 324.

Fig. 11.

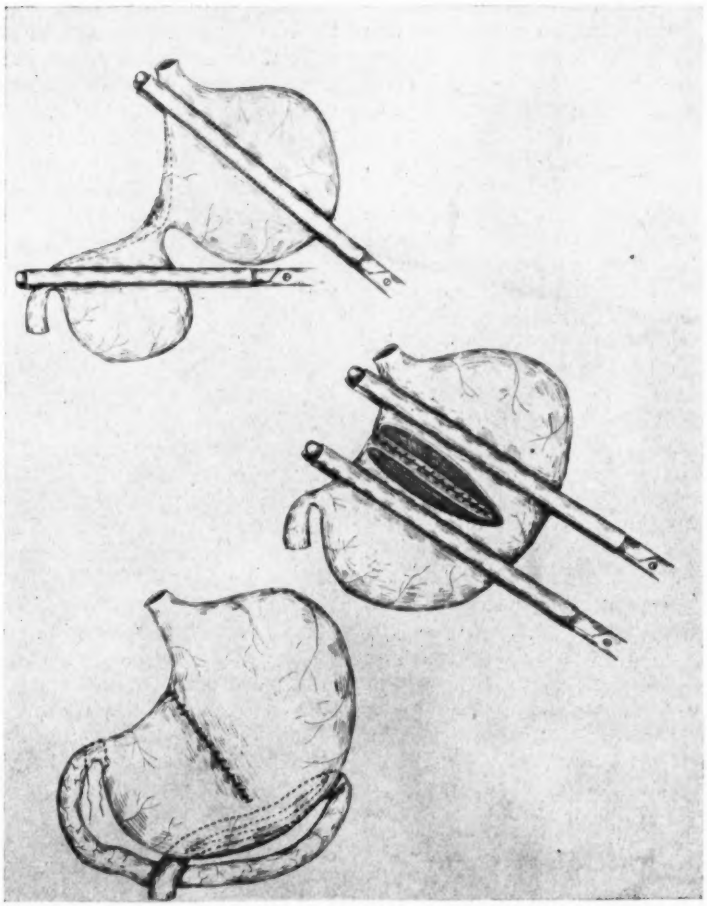


Fig. 12.

Fig. 13.

Figs. 11, 12 and 13. Author's method.

Fig. 11. Clamps placed obliquely across the stomach. The amount of the stomach wall to be excised is indicated by the dotted lines.

Fig. 12. Clamps placed parallel to one another. Suture of stomach opening commenced. The posterior seromuscular layer of sutures has been passed.

Fig. 13. Opening in stomach completely closed. Posterior gastro-enterostomy with horizontal opening performed. Silk suture passed ready to occlude pylorus but not tied.

6. *Partial gastrectomy.* In performing this operation, the pyloric stenosis, the whole of the pyloric pouch and the hour-glass constriction are excised in one piece, and thus the whole of the diseased area will be removed. This step, followed by a Polya method of lateral implantation of the end of the cardiac pouch into the jejunum, should always be performed, if possible, when the constriction is due to carcinoma. When there is no evidence of carcinoma, however, an operation of this magnitude is unnecessary and if, as is often the case, the cardiac pouch be small, there may be considerable difficulty in bringing it sufficiently far down to anastomose with the small intestine, and hence it will not be usually regarded as the operation of choice.

7. *Excision of the ulcer, pyloric occlusion and posterior gastro-enterostomy.* The theoretical objections to the treatment of a chronic gastric ulcer on the lesser curvature by a simple gastro-enterostomy have already

been mentioned. In actual practice these objections have been found to exist. For this reason, it has been my custom for some years to excise the ulcer, to occlude the pylorus and to perform a posterior gastro-enterostomy. I shall hope to show in a further communication that with the introduction of these methods, which have now been carried out in over 80 cases, much more satisfactory results have followed. Hour-glass constriction may be met with in all stages. Sometimes the ulceration is the chief factor, the stenosis is slight, and there are no symptoms of mechanical obstruction. In such instances, the treatment is that of a simple ulcer on the lesser curvature. One of my earlier cases was of this nature and satisfactory results followed this line of treatment. Where the stenosis is but slightly more marked, a similar plan will naturally be carried out, and it is indeed difficult to state at what stage of constriction treatment other than this is required. It seems wiser, even where there is marked constrction, to carry out the same operative procedure, but so to modify the lines of excision that no narrowing of the stomach results. On this line of argument, all my later cases were treated by this method with entire satisfaction. The actual steps of the operation are as follows:

In every case of an ulcer remote from the pylorus, whether situated on the posterior surface or the lesser curve which from its size is capable of excision, a clamp is placed obliquely across the stomach proximal to the ulcer and a second one distal to the ulcer. The posterior blade of each is passed in turn through the gastrocolic omentum beneath the stomach and out through the gastrohepatic omentum. The ulcer, if adherent, is then freed from the pancreas, no notice being taken of the fact that in many cases a perforation into the stomach is thereby caused. A V-shaped portion of the stomach containing the ulcer is now excised between the clamps. In no case has it ever been found necessary to perform a so-called transgastric excision. When the diseased area has been excised, the opening in the stomach is closed. The two posterior edges are first united by two rows of continuous catgut sutures. The first row commences at the apex of the V and, passing through the muscular and peritoneal coats alone, terminates at the lesser curve. The second row begins and ends at the same two points but transfixes all three coats. The two anterior edges are now united in a similar manner, the through and-through layer being in this case inserted first. The incision must be so planned that the sides of the V are at least as long as the diameter of the stomach. This can be accomplished by making them oblique, and, when the constriction is very marked, the upper limb of the V may terminate almost at the cardiac orifice. With a little care it will always be found possible to make the limbs so long that, after they have been united, the lumen of the stomach is at least 4.5 inches in diameter. At the same time every care is taken to preserve the band of normal mucosa forming the lower portion of the isthmus. The pylorus is now occluded and a posterior gastro-enterostomy performed. This is carried out in every case even if there is no trace of pyloric stenosis, for it has been clearly shown that simple excision of an ulcer on the lesser curve is insufficient. The predisposing cause of the ulceration is not corrected, and a fresh ulcer is likely to develop at the line of suture. A gastro-enterostomy alone is also insufficient, for, with an ulcer in this position, there is no pyloric spasm, and the stomach contents will continue to pass through the pylorus unless this latter structure be occluded. My own experience, however, goes to show that permanent occlusion is unnecessary and, therefore, the canal is obstructed by a simple through-and-through mattress suture of silk which is sufficient, as I have found by post-operative X-ray studies, to occlude the lumen for two to three months. A posterior gastro-enterostomy is then performed in the usual manner with clamps and two rows of catgut sutures, but instead of lying vertically it is made transversely, and is so placed that its mid-point lies opposite the line of excision of the gastric ulcer. It is for this reason that every care must be taken to preserve the mucosa in the lower part of the isthmus. If a complete segmental gastrectomy had been performed, a posterior gastro-enterostomy could not be so placed without dividing the line of suture at the junction. By making the gastro-enterostomy

in this position of the usual length, namely, about 4 inches long, the possibility of constriction at the site of excision is guarded against, for, although it is unlikely that so wide a canal would ever narrow down, yet, even if it did, the gastro-enterostomy would continue to drain both the cardiac and pyloric pouches.

The operation is simple in its performance, and is not associated with any postoperative shock. In practice, it fulfills all requirements and, as the following cases will show, is efficient in its results.

CASE 1. A. H. A married woman, age 30, was first seen on December 15, 1913. For 10 years she had suffered with dyspepsia. Her symptoms would come on in attacks lasting from 2 to 3 weeks, and then she would be quite well for several months. For the last six months, however, her symptoms had been continuous. In each attack she would have severe pain in the epigastrium passing through to the back. It would come on two hours after food and would generally be relieved before the next meal. The pain was always severe. In the early attacks there was no vomiting and the appetite was always good. In the last attacks the pain had been much more continuous; at the height of the pain she would vomit and this would always relieve the pain. She had lost a great deal of weight and her appetite was not nearly so good. On December 17 an operation was performed; the abdomen was opened by an upper right pararectal incision and an ulcer found on the lesser curvature, which had led to marked hour-glass constriction. The ulcer was excised between clamps, the lines of excision being made very oblique, so that, when the stomach was resutured, no line of constriction was left. The abdomen was then closed. She made an uninterrupted recovery from the operation, and left the hospital a fortnight later, taking a full diet and being free from symptoms. She has remained well and a letter dated May 21, 1919, states that she is now free from all symptoms.

It will be noticed that in this case the pylorus was not occluded and a posterior gastro-enterostomy was not performed. The importance of performing these steps was not at the time recognized, and it was thought that a simple excision with restoration of the caliber of the stomach would be sufficient to lead to a cure. Experience of a large number of simple ulcers on the lesser curvature has made it clear that such a procedure is insufficient, and further steps must be taken to prevent the formation of fresh ulcers.

CASE 2. N. W. A married woman, age 45, first sought treatment on November 24, 1914. For 15 years she had had attacks of stomach trouble, such attacks lasting for about a fortnight, and recurring at intervals of 6 months. During the intervals she would be perfectly free from symptoms. For the whole period she had been under more or less constant medical treatment but this had no effect in diminishing the frequency or severity of the attacks. In each attack she would have severe pain in the epigastrium and right hypochondrium which would come on about an hour after food. At the height of the pain she would vomit, and the vomiting would always relieve the pain. Eight or 9 years ago she had an attack of severe hæmatemesis, but this had not since been repeated. In spite of the pain, her appetite remained good.

The last attack had persisted for 10 weeks. The pain had been more severe, and had been more constant, although it was still increased by food. The appetite had also been failing, and the vomiting had been much more frequent; it did not completely relieve the pain, and she had lost a considerable amount of weight. On examination she was considerably wasted, there were no definite physical signs beyond tenderness in the epigastrium, but an X-ray examination after an opaque meal showed a definite hour-glass constriction. The test meal showed the presence of .10 per cent free hydrochloric acid and a total acidity of 50. On November 26, an operation was performed, and a large ulcer was found on the lesser curvature which was adherent to the pancreas and liver. This had led to marked constriction of the lumen of the stomach. A second ulcer was found at the pylorus which had also caused stenosis. The ulcer at the lesser curve was widely excised, the pylorus occluded, and a posterior gastro-enterostomy performed. The patient made an uninterrupted recovery, and was discharged from hospital 16 days later.

In January, 1915, she was readmitted to the hospital with a carcinoma of the left breast which was excised. She was quite free from stomach trouble and had had no return since leaving hospital. Since then she has remained free from gastric symptoms. A letter dated May 21, 1919, states that she is able to take all her food well, and, beyond an occasional attack of diarrhœa, is free from all symptoms.

CASE 3. S. P. A single woman, age 30, was first seen on March 16, 1914. She had had attacks of abdominal trouble for 10 years, each attack would last a few weeks and she would then be free for several months. In the attacks there would be severe pain in the epigastrium, commencing about an half-hour after food. At the height of the pain she would vomit and the pain would then be relieved. On two occasions 10 and 6 years previously she had had severe attacks of hæmatemesis for which she had prolonged medical treatment.

For the last two years the attacks had been becoming much more frequent and had now become

almost continuous, although the pain was less severe. Her appetite had been diminishing, she had lost three stone in weight, and vomiting had been much more frequent but did not give the same relief as formerly.

There were no definite physical signs although an opaque meal showed a definite constriction. The test meal showed the presence of .05 per cent free hydrochloric acid and a total acidity of 41. On March 18, she was operated upon and an old ulcer found on the lesser curve which had led to marked constriction. The ulcer was excised as a wide wedge, the pylorus occluded and a posterior gastro-enterostomy performed. She was discharged from hospital free from symptoms 14 days later. On January 26, 1915, she stated that she had had very good health, she was taking all her food well, and had been quite free from pain and vomiting.

CASE 4. S. M. A single woman, age 21, was first seen on February 19, 1916. She had had attacks similar to those in the last cases for 2 years, but for the last 6 months had had more continuous pain, increased in severity. She had been losing weight and her appetite was poor. The test meal showed the absence of free hydrochloric acid and total acidity of 19. An operation was performed on February 23, and a large ulcer found on the lesser curvature adherent to the liver and pancreas. It was widely excised, the opening closed, the pylorus occluded and a posterior gastro-enterostomy performed. She was discharged on March 10 free from all symptoms. Two months later she was able to return to heavy work at a laundry, being free from all symptoms. In June, 1917, she had continued to remain free from symptoms and was doing all her work well. A letter dated May 19, 1919, states that she is still free from gastric symptoms and can eat and drink anything.

CASE 5. C. A. A married woman, age 36, was seen on June 5, 1916. She had had symptoms in characteristic attacks for four years, but for the last 6 months they had been almost continuous. During this period she had shown considerable wasting and, on examination, a round mass, the size of an egg, could be felt to the left of the umbilicus. An X-ray after an opaque meal showed the stomach divided into two areas united by a narrow canal. An operation was performed on June 7, an hour-glass stomach being found. The constriction was about three-fourths inches in diameter and showed an indurated ulcer at the lesser curve. The ulcer was situated to the pyloric side of the constriction and the constriction itself was due to a fibrous scar of the old partly healed ulcer. A wide V excision was performed around the ulcer and scar, and the edges united. Owing to the space between the two and the strain required to unite them, silk was used for the posterior layer of sutures. The pylorus was now occluded and a posterior gastro-enterostomy performed. She made an uninterrupted recovery, and remained free from symptoms until October 21. She was seen again on November 7, complaining of severe pain, similar to that before operation, accompanied by vomiting, and the test meal showed .09 per cent free hydrochloric acid, total acidity 48. She was readmitted to hospital and a second operation performed. No constriction was found at the site of the old operation, but, at the lower part of the resection posteriorly, an ulcer was found adherent to the pancreas. The stomach was opened anteriorly and in the base of the ulcer was found a portion of the silk suture. A partial gastrectomy was performed and the cardiac end of the stomach embedded in the lateral aspect of the jejunum. She has made uninterrupted progress and when last seen on March 14, 1919, she was free from all symptoms.

It is interesting to note that in this case there was a recurrence of the ulcer. As is so often the case with gastrojejunal ulcer, this was clearly due to an error in technique. Owing to the fear of tension, a silk suture was used on the posterior surface; a portion of this suture had ulcerated into the stomach and given rise to a chronic ulcer. Since this case chromic catgut has alone been used as in all other operations upon the stomach.

CASE 6. M. M. A married woman, age 24, was first seen in November, 1918. There had been a six years' history of attacks, which had become more frequent and more severe. She had been wasting, and vomiting was increased. The X-ray report showed a penetrating ulcer on the lesser curve with a bilocular stomach. Test meal .09 per cent free hydrochloric acid, total acidity 45. An operation was performed on November 28, and a chronic ulcer found adherent to the pancreas with a marked hour-glass constriction. It was excised in a wide V, the pylorus occluded, and a posterior gastro-enterostomy performed. She made an uninterrupted recovery and up to the present date has been free from all symptoms.

CASE 7. A. G. A single woman, age 34, was first seen on July 3, 1918. She had had attacks of indigestion since childhood. The attacks showed the characteristic symptoms, and of late the pain had become more constant but less severe; there had been wasting and loss of appetite.

At operation an old ulcer was found at the lesser curvature with hour-glass constriction. The pylorus was narrowed by scar tissue. The usual operation was performed, from which the patient made an uninterrupted recovery and has since remained free from symptoms. The last note dated May 18, states that there were no symptoms and she is able to take all food well.

CASE 8. L. A. A married woman, age 24, first sought treatment on March 3, 1919. She had suffered with indigestion for nine years, consisting of more or less continuous discomfort after food. There were, however, attacks of more severe pain characteristic of chronic gastric ulcer. For the last six months,

the severe pain had been more constant, and was associated with frequent vomiting which only in part relieved the pain. At the age of 18, she had several severe attacks of hæmatemesis. The test meal showed absence of free hydrochloric acid and a total acidity of 54.

On March 6, an operation was performed, and a lesser curve ulcer with an hour-glass constriction found. This was treated in the usual way by excision, occlusion of the pylorus, and posterior gastro-enterostomy. The gall-bladder was then found to contain a large single stone which was removed and the gall-bladder drained. The patient made an uninterrupted recovery, but, one month later she still had occasional slight pain. This has since improved, and, although the interval is too short to say that a cure has resulted, she is now free from symptoms.

CASE 9. G. B. A married woman, age 22, had been under medical treatment on and off for 5 years. There were attacks of severe pain after food accompanied by vomiting. For 3 months the pain had been more continuous and more severe, and the vomiting had been more frequent; during the same period there had been considerable loss of weight and the appetite had not been so good. She was transferred to the surgical department on March 10, 1919. Test meal showed free hydrochloric acid .11 per cent, total acidity 52. The opaque meal showed a bilocular stomach with a penetrating type of ulcer on the lesser curvature.

The usual operation was performed on March 13, from which she made an uninterrupted recovery. A month later she was on full diet with no pain or vomiting and was living a normal life.

CASE 10. N. P. A married woman, age 47, had suffered with gastric symptoms for 33 years; during this time they had occurred in the characteristic attacks, the pain coming on about half an hour after food. The symptoms had changed in the last two and a half years, the pain becoming more severe and more continuous. For the last six weeks there had been no relief at all. During this later period vomiting had been more frequent and she had been losing her appetite. Two and a half years ago she had had two attacks of hæmatemesis. On examination there was well-marked visceroptosis with splashing over the stomach. The test meal showed free hydrochloric acid. 12 per cent; total acidity 54. The X-ray showed a marked depression on the greater curvature with a bilocular stomach.

On April 10, 1919, an operation was performed. A chronic gastric ulcer was found with an hour-glass constriction. This was treated in the usual way by excision with pyloric occlusion and posterior gastro-enterostomy. The operation was followed by uninterrupted recovery, and she has remained free from symptoms up to date.

THE TREATMENT OF WAR WOUNDS OF THE JOINTS

By PROFESSOR PIERRE DUVAL, Paris, France

AMONG the different kinds of war wounds, there are few the treatment of which has undergone such radical and satisfactory change as has that of wounds of the joints. In 1914, we must admit that very little was known about war wounds of joints, and the general regulations concerning the evacuation of these wounded were such that they were sent to the very distant hospitals and when finally the wounded arrived for the attention of the surgeon infection was well advanced.

The radical change that has taken place in the surgical treatment of wounds is due to two related causes: first, the fact that the joints resist infection and second the adoption of the practice of operating as early as possible in the lines. The comparative results are as follows:

During 1914 and 1915, in war wounds of the knee, the death rate was 27.6 per cent; during the same period amputation of the thigh was done in 30 per cent of the cases. During 1916, 1917 and 1918, the death rate was 0.9 per cent and amputation was done in 2.8 per cent of the injuries. In 1914 and 1915, a soldier wounded in the knee was generally sent either immediately to distant parts of France or operated upon at the army hospital, by simple arthrotomy and drainage; from 1916 on, such injuries were operated upon in the lines by complete surgical cleaning and immediate suture. Thus, for the practice of late operation and simple drainage, was substituted immediate operation and complete closure of the joint.

Immediate suture of a joint, that of the knee for instance, was done the first time in 1915 by Delore, of Lyon; in 1916, during the battle of Verdun, it became the general practice of Loubat; it was adopted by Gaudier in the same year; and during the battle of the Somme, July to December, 1916, this practice became the rule. Immediate suture is based on the following principles: a war wound of a joint, like any other war wound, is contaminated directly by germs which are carried into the wound by shot and fragments of clothing. Infection develops, but the defensive reaction of the synovial membrane is much more efficacious than that of other tissues; the synovial membrane seems to possess a bactericidal power. If a wound is examined bacteriologically a few hours after receipt, the usual bacteria (aerobes and anaerobes) are found in the skin, the muscles, and the aponeurosis. The tissues and the clothing contain a great number of bacteria. If the bones have been injured the surfaces of the fracture are contaminated and the edges

Fig. 1. Result 9 days after operation in wound of the fossa beneath the quadriceps (1918).

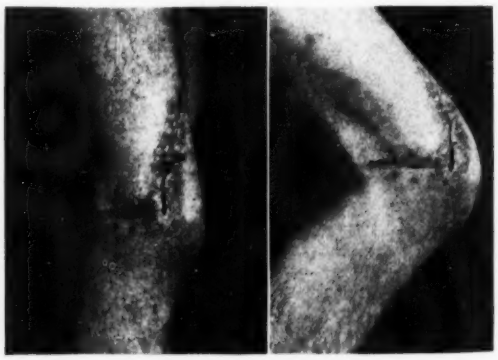


Fig. 2. Result 23 days after operation in wound of the right knee and of the synovial membrane (1918).

Fig. 3. Result 23 days after operation in shell wound of the knee (1918).

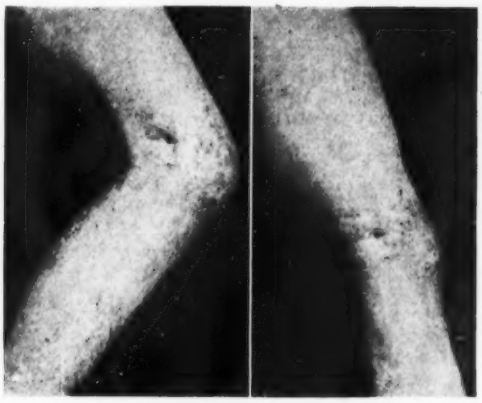


Fig. 4. Result 42 days after suture wound of the calf and knee (1918). The shot entered the calf and lodged in the condyle. Primary suture of the knee and secondary suture of the calf.

of the torn synovial membrane are also contaminated, but the synovial fluid, the blood and serum are without bacteria. This aseptic state of the synovial membrane persists for a relatively long time — 24, 48 and sometimes even 60 hours — before the septic arthritis develops. There is then a long, intermediate period during which the cavity of the joint remains aseptic while the parasynovial wounds are contaminated, even infected. It is in this intermediate period that operation should be done. On the other hand an appropriate operation permits the excision of all the contaminated tissues even the bone tissue, the resection of the contaminated edges of the synovial perforation, the removal of all foreign material — the bearers of infection — and it is after this has been done, that is when the surgical wound and the joint cavity are aseptic, that complete suture without drainage should be done.

Our bacteriological studies made in the course of the operation have shown the following results: In wounds of the soft parts, in the edges of the perforated synovial membrane, on the shot and fragments of clothing and on the fractured bone surfaces, germs may be found present, but the joint fluid is without bacteria.

After operation, consisting in excision of the wound of the soft parts, the removal of shot and fragments of clothing, and the cleaning of the bone at the site of fracture, all previous deductions as to the presence of

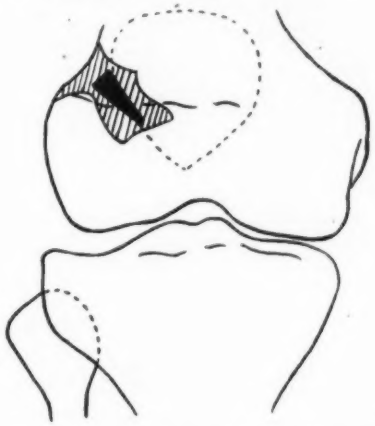


Fig. 4a. Schematic drawing showing destruction of bone.

bacteria in the wound, that is in the muscles, aponeurosis, bone and synovial fluid have been confirmed by negative results on culture.

Total immediate suture of wounds of the joints, preserving the maximum amount of bone surface was adopted generally only in 1917; the year 1916, represented for us a period of hesitation and groping which is easily explained. Early in 1915, under Tuffier's influence typical immediate resection seemed to be the best means of preventing infection of the joint with its fatal results, and this

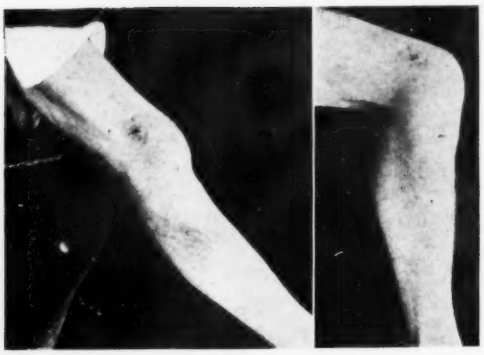


Fig. 5. Result 17 days after suture in wound of the knee made by fragment of shell (1918).

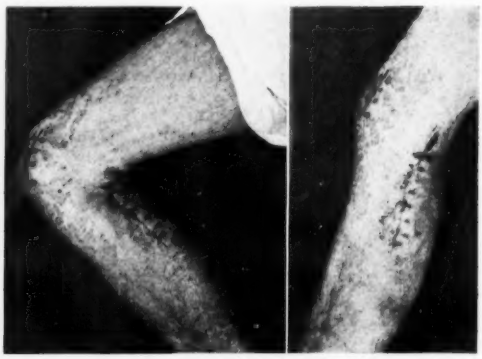


Fig. 6. Result 28 days after suture in gunshot wound of the knee (1918).

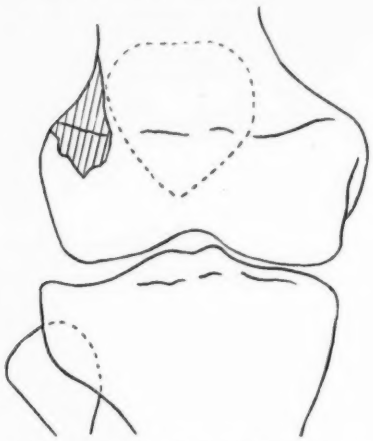


Fig. 5a. Schematic drawing showing destruction of bone.

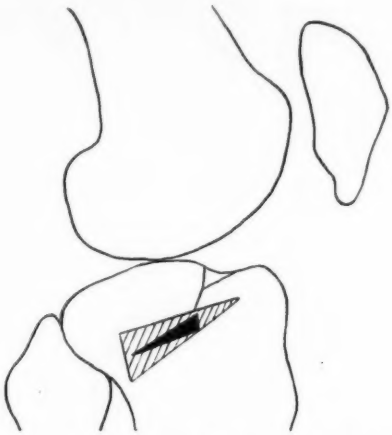


Fig. 6a. Schematic drawing showing destruction of bone.

practice we must acknowledge saved many lives. Then a few surgeons advised as a measure of safety, closure of the synovial cavity without suture of the wound of the soft parts; others the introduction of a drain in contact with the closed synovial membranes and others total suture but to make a drainage opening either at the site of the suture or on the summit of the *foss sous tricipital* of the knee.

All these measures called "safety" measures were soon found to be unsafe measures and total suture of the whole wound was gradually found to be the least dangerous practice. At first the immediate results were excellent but the surgeons farther back from the lines soon warned us of functional results which were termed by them as unsatisfactory; stiffness of the joints, partial ankylosis, etc.

The Lyons school praised then most energetically immediate typical joint resection, not according to Tuffier's idea, to prevent joint infection but to obtain better functional results. May I be allowed to say that I have been one of the more ardent adversaries of that doctrine?

Total immediate resection must be done only to smooth out very serious injuries of one or both bones of a joint when the injury itself has really accomplished resection.

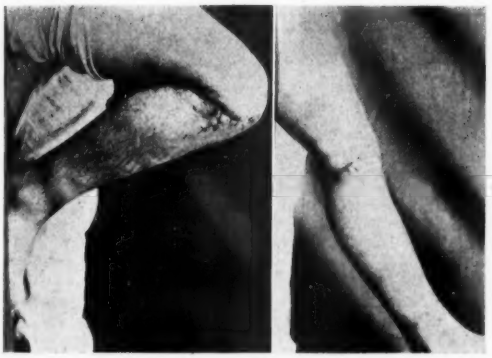


Fig. 7. Result 13 days after suture in wound of the knee made by shell fragment (1918).

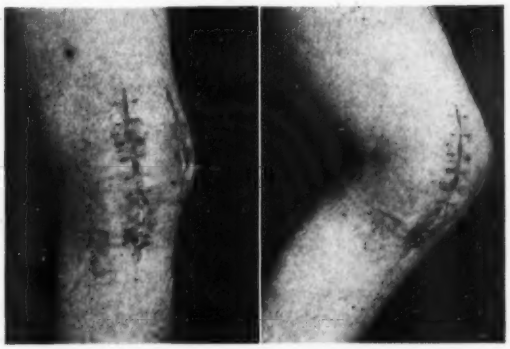


Fig. 8. Result 52 days after suture in wound of the knee from fragment of shell.

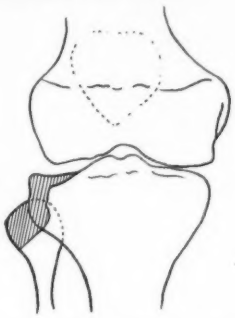
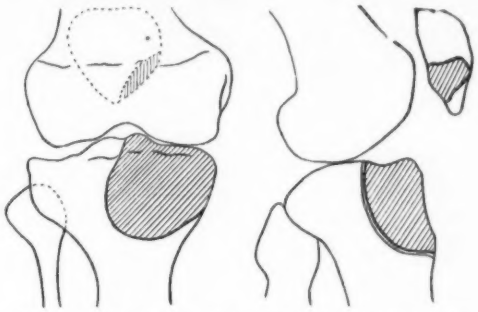


Fig. 7a. Schematic drawing showing destruction of bone.



Figs. 8a and b. Schematic drawings showing destruction of bone.

In war wounds of the joints the utmost must be done to save the limbs. If through misfortune the functional result is bad, a secondary economical resection can be done at a later period. The gradual development of a better technique permitted saving fragments of bone which were useful in the anatomical reconstruction of joint surfaces. At the elbow a partly detached condyle has been preserved and put back in place; at the knee, fracture of the patella has been regularly treated by suture of the bone and the same is true of fracture of the olecranon at the elbow; at the ankle-joint the astragalus has often been partly preserved; at the knee, in short, condylar fractures of the femur and tibia have been treated conservatively and even by immediate wire suture, after complete cleaning.

Functional results have rapidly improved, the patients operated upon have been sent on to special hospitals for mobilization of the joints. The adoption of the method of Willems, of Ghent — active mobilization immediately after operation—has really improved, in a great measure, the functional results of early operation upon joints.

In 1917 and 1918, the surgical treatment of war wounds of the joints was based on the following principles:

1. Operation as early as possible.
2. Complete operation, that is removal of all foreign substances; total excision of the track of the missile.
3. Careful cleaning of fractured surfaces, complete suture of joint, without drainage.
4. Active and immediate mobilization.
5. Preservation of parts to as great an extent as possible, immediate resection being limited to injuries with extensive comminution.

The technique varies with each case accord-

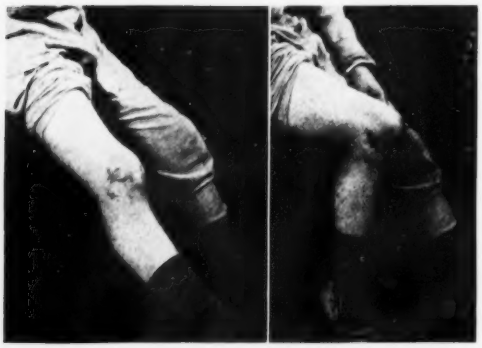


Fig. 9. Result 47 days after suture in shell wound of the knee with partial fracture of the external upper tibia (1917).

ing to the location of the wounds of the soft parts. As a general rule there are two methods of procedure: (1) treating the peri-articular wounds first, gradually proceding to the joint and (2) treating the joint injury first and then treating the peri-articular wounds. Personally I have always performed arthrotomy first so as to clean the joint, then I treat the fractured bone surfaces, resect the perforated synovial membrane and suture, closing the joint before excising and suturing the wound of the soft parts. I must acknowledge, however, that the surgeons who begin by treating the wounds of the soft parts and finally doing arthrotomy have obtained splendid results. The technique really varies with each case.

The arthrotomy incision must be ample; for the elbow, external lateral incision, internal lateral and the mid-line posterior incision for the very frequent posterior wounds. To expose the joint clearly I have always practiced section of the external lateral ligament which permits opening the elbow-joint widely, jerking the forearm toward the inside. This section performed in this way followed by well executed reconstructive suture, does not in the least compromise the function of the elbow-joint.

For the knee two methods are in use: the U arthrotomy with section of the patellar ligament and the unilateral or bilateral arthrotomy. In 1916, I showed the advantage of the U arthrotomy for all joint wounds with injury to the bones. Some cases of functional

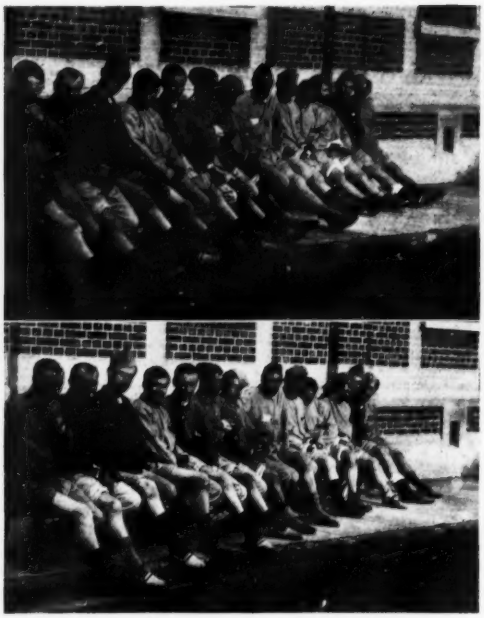


Fig. 10. Photographs of 13 patients with wounds of the knee bone, wounds in all, operated upon in 1917 (Flanders), showing the result the first month after injury.

disability due to section of the patellar ligament have been pointed out. On the other hand ample lateral arthrotomy has given favorable results and the following conclusion has been reached:

The U arthrotomy must be reserved for extensive wounds of the bones as well as for posterior or intercondylar wounds, for it alone permits in these cases the right treatment of bone surfaces. For posterior wounds or wounds of the popliteal space with deep seated injury to the condyles or of the back part of the tibia, U arthrotomy alone permits proper treatment of bone injuries. In such cases the arthrotomy is followed by treatment of the popliteal wound. But for lateral wounds of the condyles of the femur or the tibia, in lateral wounds of the patella and in simple perforations of the synovial membrane, the large unilateral or bilateral arthrotomy is the method of choice. Transpatellar arthrotomy is not suitable for fresh war wounds of the knee. At the ankle, the

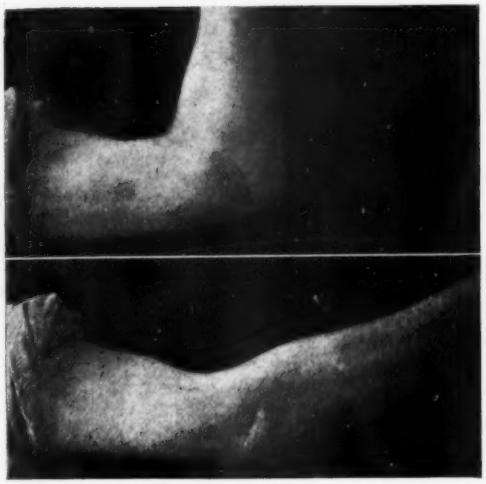


Fig. 11. Result 18 days after suture in wound of the elbow from fragment of shell (1918).

Fig. 12. Result 23 days after suture in wound of the elbow made by fragment of shell (1917).

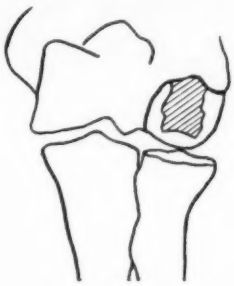


Fig. 11a. Schematic drawing showing destruction of bone.

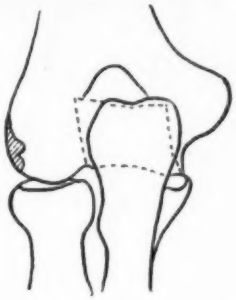


Fig. 12a. Schematic drawing showing destruction of bone.

shoulder, and the wrist, the incision varies with the size of the wound.

The treatment of limited bone injuries is the capital point of the technique. Limited injuries in which there are fragments of shell are treated by ablation of the foreign bodies and careful cleaning of the joint cavity. Bacteriological observation shows that, after cleaning, the bone tissue is without bacteria.

The bone tissue infiltrated with blood must not be cleaned too vigorously. When one operates at the most opportune time, that is 8 to 12 hours after receipt of injury, the cleaning must be superficial. An important question to decide is whether a bone cavity which continues to bleed more or less should be left open in the joint. When the bone injuries are lateral and at the same time are extra-articular or intra-articular, by proper suture of the synovial the cavities are separated from the joint.

But what is to be done in other injuries? Experience shows that these bone cavities well cleaned can be left open in the joint. Some surgeons have obtained successful results by filling the cavities with wax or compact aseptic substances. Often I have filled the cavities with a muscular bit of flesh pedicule which acts as a hæmostatic agent. All these methods are good.

Fig. 13. Result 18 days after suture in wound of the elbow from shell fragment (1918).

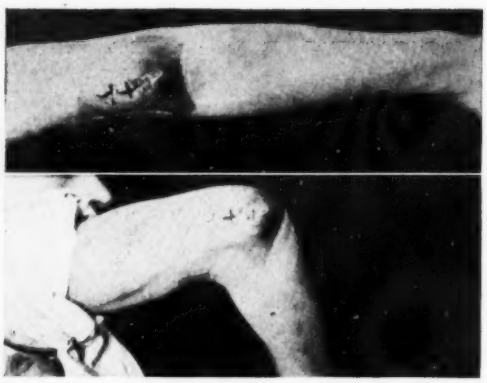


Fig. 14. Result 9 days after suture in wound of the elbow from fragment of shell (1918).

Fig. 13a. Schematic drawing showing destruction of bone.

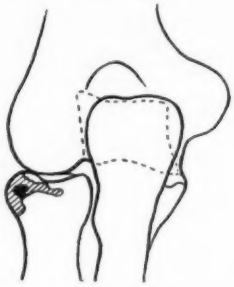


Fig. 14a. Schematic drawing showing destruction of bone.

When the bone injury is complicated by the presence of fissures more or less extensive the treatment must be the same as for all fractures. After scraping the center of the fracture the fissures must be opened with a lever of any kind so as to scrape the walls of the fissures; then the bone fragments thus displaced must be replaced. If the bone fragments cannot be correctly maintained in place so as to re-establish the joint surface as much as possible, one may or must resort to nails or screws. This must be done in injuries to the condyles of the femur, of the tibia, of the humerus, or of the deep part of the patella.

Once the joint is well cleaned we have a surgical aseptic wound and the operative procedure must be the same as for a closed fracture of a joint.

The most important result to be obtained is the re-establishment, as far as possible, of a normal joint outline. Experience has shown that good functional results can be obtained even when there is a partial loss of joint surface if the general outline of the joint surface has been preserved. The series of roentgenograms and diagrams which are published here prove this quite conclusively.

The treatment of perforations of the synovial membrane is important. Usually the edges of the synovial aperture are bruised, lifeless from traumatism, and contaminated by bacteria from the wound. Therefore, it is necessary to treat them as we do all war wounds, first by excision and then by suture. Personally when I do a U arthrotomy I begin the operation by excising the damaged tissues of the synovial; in lateral arthrotomies, I

Fig. 15. Result 9 days after suture in gunshot wound of the elbow (1918).

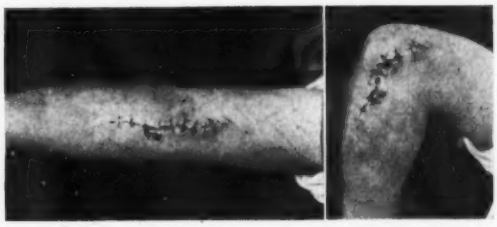


Fig. 16. Result 11 days after suture in wound of the elbow caused by fragment of shell (1918).

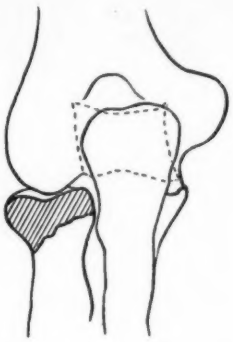


Fig. 15a. Schematic drawing showing destruction of bone.

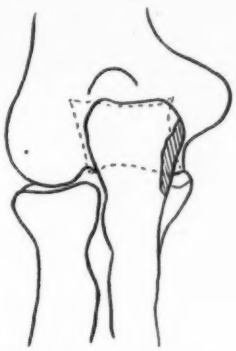


Fig. 16a. Schematic drawing showing destruction of bone.

start from the outside of the wound and work toward the joint.

The treatment of the serous fluid in the joint is most important. The serous liquid must be dried up as completely as possible with dry sponges in all parts, so as to leave neither blood nor fibrinous coagulum. This is so important that at the elbow, I do not hesitate to section the external lateral ligament.

Up to 1918, before placing the last suture, almost all surgeons poured ether into the joint and rubbed the surface of the bone with a sponge saturated with ether. By degrees this antiseptic treatment has been abandoned and joint surgery has become purely aseptic.

The terminal suture is made layer by layer, preserving as much as possible the ligamentous, fibrous and muscular planes periarticularly. No drainage is used.

War wounds of joints are frequently accompanied by extensive muscular peri-articular destruction. It is most important to repair grave injuries to the important muscles. There are two muscles for which this repair is of first importance—the arm triceps and the thigh quadriceps extensor.

Fig. 17. Results 37 days after suture in wound of the elbow by fragment of shell (1917).

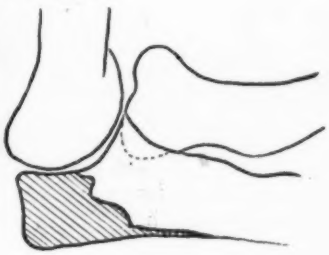


Fig. 17a (at right). Schematic drawing showing destruction of bone.

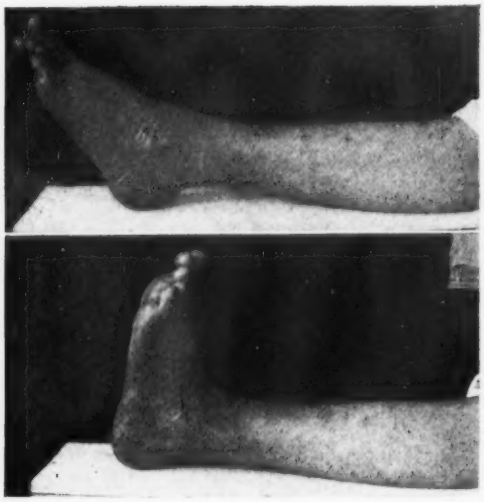


Fig. 18. Result 12 days after suture in gunshot wound of the tibiotarsal joint (1918).

Fig. 19. Result 13 days after suture in seton wound of the astragalus.

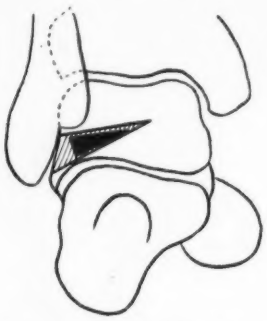


Fig. 18a. Schematic drawing showing destruction of bone.

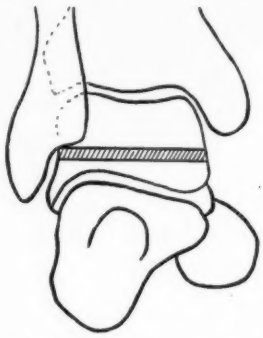


Fig. 19a. Schematic drawing showing destruction of bone.

During 1917 and 1918 my fellow workers and I practiced immediate muscular and tendinous autoplasties. Our results were very good. In traumatic destruction of the olecranon, repair of the triceps by autoplasty and reimplantation on to the olecranon are absolutely necessary.

The after-treatment has passed through various phases. Joints thus operated upon were first absolutely immobilized in plaster apparatus for two or three weeks. This period was later shortened to a few days' duration.

The method of Willems, of Ghent, is now used. Active immediate mobilization of joint injuries, insures ultimate perfect functional results even in cases of comparatively extensive bone destruction. We must acknowledge that this method is a real step forward in joint surgery.

Those who have watched the continual progress which has been made from 1916 to 1919, say that they can conceive no limits to the results which can be obtained from aseptic surgery of joint wounds. In the last

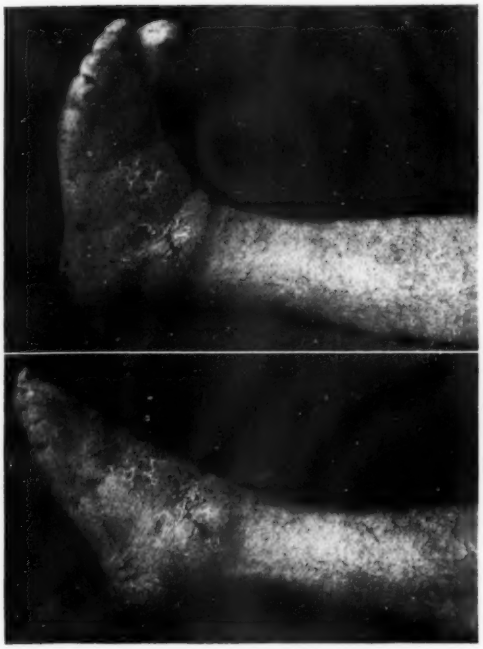


Fig. 20. Result 25 days after suture of the extensor tendons in severe wound of the astragalus (1918).

Fig. 21. Result 11 days after suture in gunshot wound of the astragalus and calcaneum (1918).

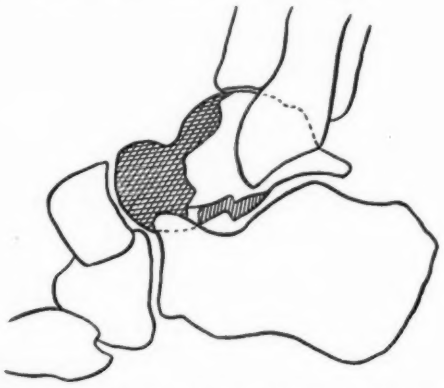


Fig. 20a. Schematic drawing showing destruction of bone.

Fig. 21a. Schematic drawing showing destruction of bone.

German offensive the inevitable delay in bringing in the wounded delayed their removal to the hospitals 24 to 36 hours. But still joint surgery gave good results.

What then are the limitations of this aseptic and preserving surgery of joint wounds?

It is advisable to examine them first as to the length of time elapsed between injury and operation; second as to injuries to bones which can be treated by preservation. According to the rule, 24 or even 36 hours after injury joint surgery may be applied. Some-

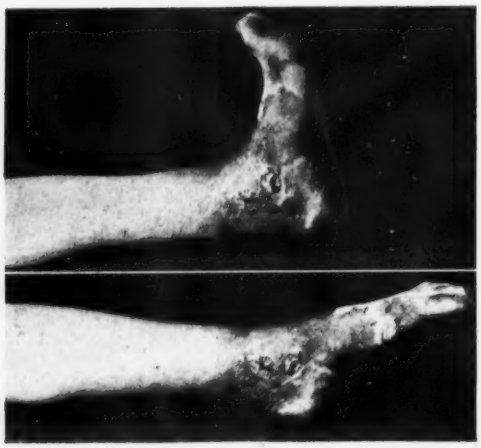


Fig. 22. Result 12 days after suture in wound of the internal ankle by fragment of shell (1918).

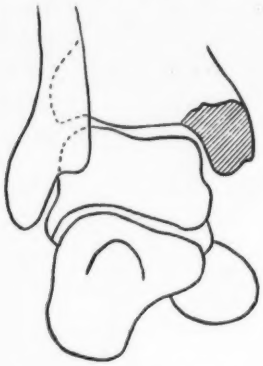


Fig. 22a. Schematic drawing showing destruction of bone.

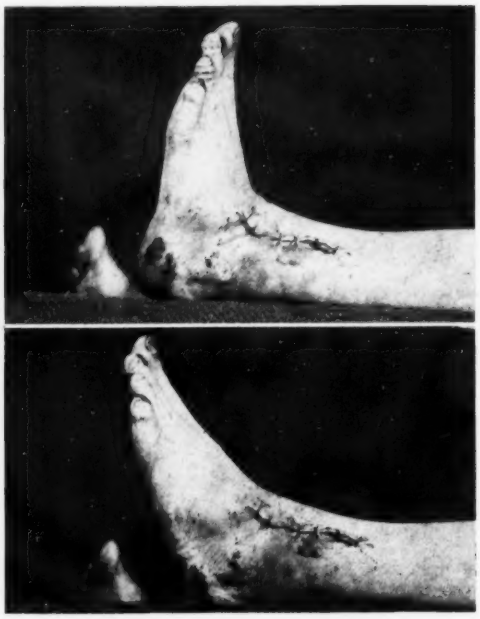


Fig. 23. Result 5 days after suture in extensive comminution of the tibia by fragments of shell (1918).

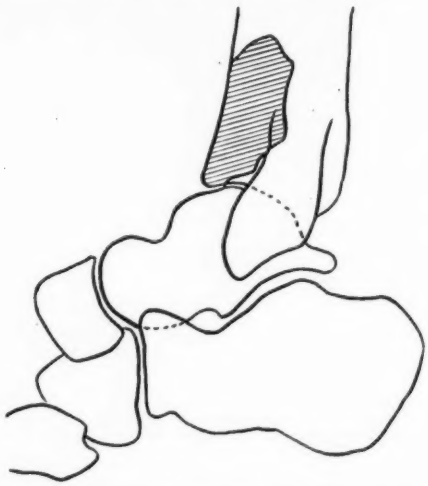


Fig. 23a. Schematic drawing showing destruction of bone.

times at this time, but often later, one may find the following condition: a swollen knee which is painful and on incision, a suspicious liquid which on examination is found to contain bacteria, and few or no injuries to the bones. In such cases what is the best method to use? Joint drainage brings disaster. We have all reached the same conclusion: that even in these doubtful cases it is best to follow the same technique; to suture the joint. If purulent arthritis develops, early resection gives excellent results. Personally, in cases of arthritis with anaerobic germs, I have obtained cures by injecting into the joint antimicrobian serum. Unfortunately we have nothing with which to combat the streptococcus.

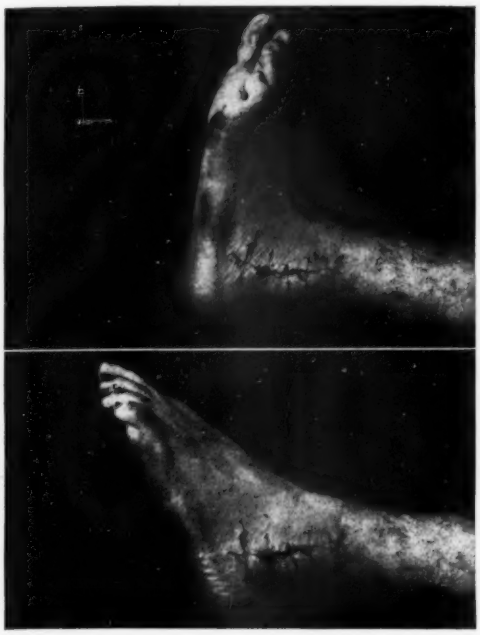


Fig. 24. Result 8 days after suture in wound of the fibula and astragalus (1918).

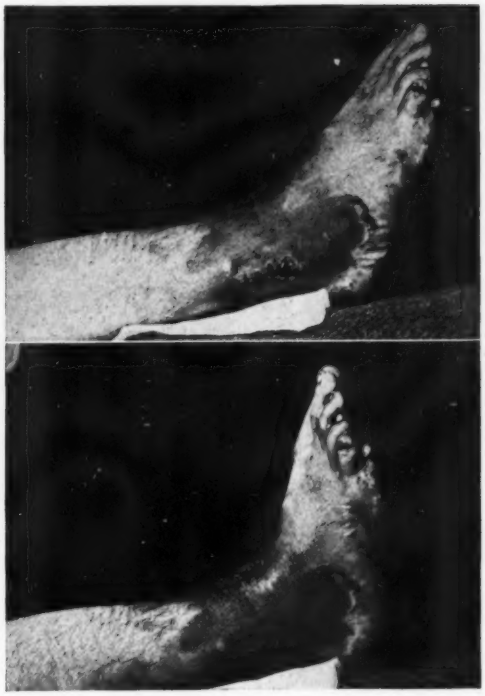


Fig. 25. Result 13 days after suture in severe gunshot wound of the astragalus and fibula (1918).

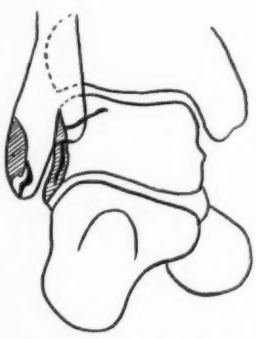
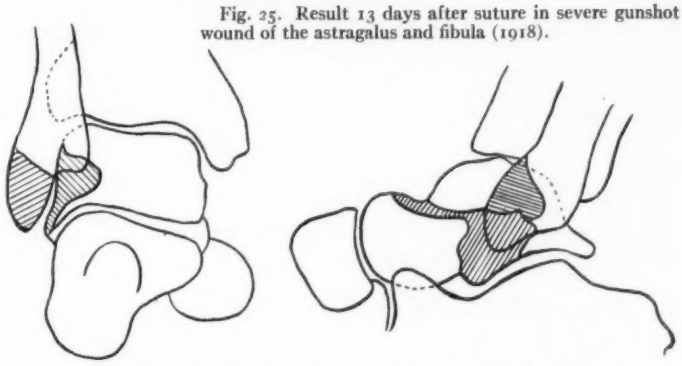


Fig. 24a. Schematic drawing showing destruction of bone.



Figs. 25a and b. Schematic drawings showing destruction of bone.

What is the limit of preservation in epiphyseal fractures? One may say that in a general way all fractures must be treated with the idea of preserving the epiphyses at any cost.

When trabecular fractures are complicated by fissures, one must still attempt preservation, for it gives fine results; but in case of failure, it is better to practice early resection. At the elbow or at the knee should a fissure loosen a condyle, the fragment of bone must be replaced after cleaning. One of my pupils, Gatlier, has even replaced a femoral condyle which had become completely detached; he

Fig. 26. Result 13 months after suture in wound of the knee and ankle by fragment of shell (1917).

took it out of the joint, cleaned and replaced it — a real immediate graft — and the functional result is good.

Immediate resection must, therefore, be practised only exceptionally in cases of serious fractures of the joint surface. But if a rather

Fig. 27. Result 21 days after suture in wound of the wrist by fragment of shell (1917).

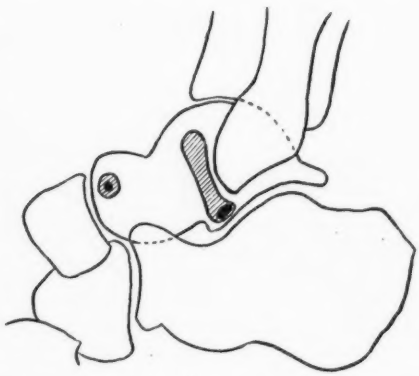


Fig. 26a. Schematic drawing showing destruction of bone in ankle-joint.

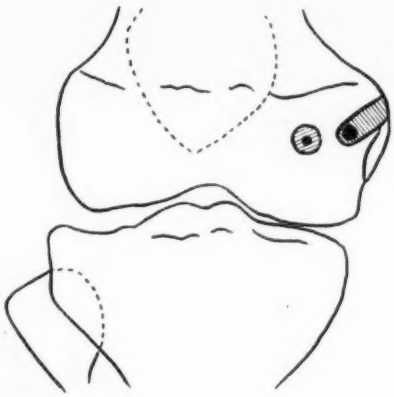


Fig. 26b. Schematic drawing showing destruction of bone in knee-joint.

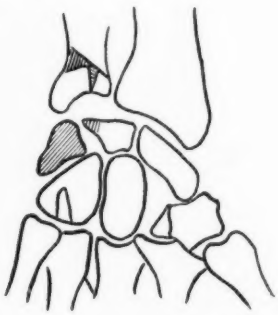


Fig. 27a. Schematic drawing showing destruction of bone in wrist-joint.

Fig. 28. Wound of the wrist by fragment of shell. Result after 10 days (1918).

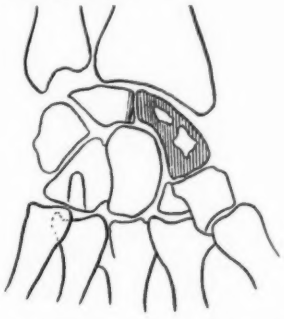


Fig. 28a. Schematic drawing showing destruction of bone.

daring attempt at preservation has been made and if one foresees a failure, resection must be done at once as a corrective operation.

All injuries to joints must be treated according to these general principles. In the hip only is it thought advisable to do resection directly. At the elbow, wrist, shoulder, knee, and ankle, aseptic and highly preservative surgery gives extraordinary results.

The series of photographs included in this article shows, next to the functional result, how extensive were the bone injuries treated.

Fig. 29. Result after 32 days in gunshot wound of the wrist (1918).

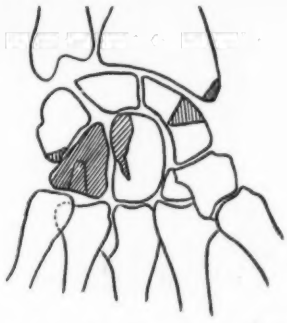


Fig. 29a. Schematic drawing showing destruction of bone.

To give a general idea of the revolution which has taken place in joint surgery during the war, I append my personal statistics. During 1915 war wounds of the knee were treated in the lines by arthrotomy and drainage and cared for in our territory with a death, rate of 27.5 per cent. Amputation of the thigh was done in 30 per cent of the cases. During 1916, 1917 and 1918, war wounds of the knee were treated in the lines by total suture and express preservation. In 130 cases there were 21 immediate resections with 4 deaths; resection was not done in 104 cases. There were 86.5 per cent complete cures, 9.6 per cent comparative failures, 2.8 per cent amputations, 0.9 per cent deaths.

THE TREATMENT OF METASTATIC CARCINOMA OF THE SPINE BY DEEP ROENTGENTHERAPY

With the Report of Four Cases, and Remarks on Pre-Operative Treatment of Carcinoma[1]

By GEORGE E. PFAHLER, M.D., Philadelphia

THE object of this paper is to prove that deep roentgentherapy will bring about a healing process in deep seated carcinoma. Every one will acknowledge that metastatic carcinoma of the spine is not a superficial disease. It is not the object of this paper to recommend roentgentherapy in the treatment of such advanced carcinoma. It is my belief that when metastatic carcinoma of the spine has developed, we are dealing with the beginning or with a part of a general carcinomatosis, and not with a localized area of disease. It is also my belief that when one has general carcinomatosis to deal with, in which there is a local manifestation giving rise to most of the symptoms, one can influence this local disease but we can not expect to get the patient really and permanently well by any means that we know today. The life of the patient can be prolonged and made more comfortable but later some area in the body, which has escaped treatment or has been unsuccessfully treated, will make itself manifest.

The second object of this paper is to encourage the use of the roentgen-rays in the early treatment of carcinoma, by proving that a favorable and curative effect can be produced upon carcinomatous tissue, even in an advanced stage, and if this fact is proved there should be no other proof needed to establish this form of treatment as a method of choice in the early treatment of carcinoma. By this I do not mean that we should replace surgery or that we should replace any other method that has been proved efficacious in

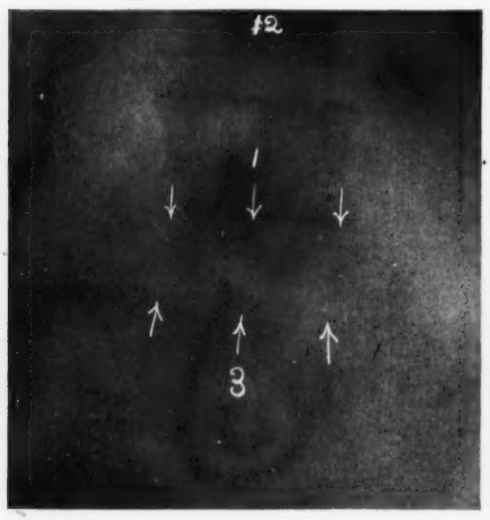


Fig. 1. Case 4, showing complete destruction of the second lumbar vertebra, due to metastatic carcinoma. Examination made six months after the primary operation upon the breast. Patient had been bedfast three months.

Fig. 2. Case 4, showing second lumbar vertebra healed and recalcified. The patient is free from symptoms, has gained 30 pounds in weight and does all her general housework, including washing and ironing.

[1]Read before the annual meeting of the Eastern Roentgenologists at Atlantic City, January 24 and 25, 1919.

the removal of the disease, but I do most earnestly wish to discourage the practice of waiting for the use of the roentgen-rays until general carcinomatosis has taken place, or until metastasis has taken place, or until there is an extensive recurrence following operation. All of the cases of metastatic carcinoma of the spine, which I am about to report, had primary carcinoma of the breast.

Ante-operative treatment. It is my opinion that the ideal method of treatment of carcinoma of the breast or carcinoma elsewhere, in the light of our present knowledge, consists of a thorough course of X-ray treatment preceding the operation, in which the disease is treated from every angle, and in which the lymphatic areas draining the breast are included in this ante-operative treatment. Within a few days, or as soon as it can be practically arranged after this preliminary course of X-ray treatment, I believe that a complete operation should be performed. Then following this operation, at the end of four weeks from the time the first course of X-ray treatment was given, a second or postoperative course of treatment should be given and these courses of treatment should be repeated at intervals of a month or more. Three to eight such courses or series of cross-firing will suffice; a general average is about five. In this way I believe the best possible results and the greatest number of cures of carcinoma can be obtained. Whenever it has been possible during the past two years or more I have carried out this plan of treatment.

This ante-operative treatment is based not only upon clinical observation but upon experimental work. Colwell and Russ[1] and Nogier, Jaubert de Beaujeu and Contamin[2]; have shown the direct effect of the X-rays upon the cells of an adenocarcinoma of a mouse. The tumor upon removal from the animal was minced and then exposed to X-rays after which it was inoculated into normal mice to see whether it would grow. A typical example showing how the subsequent growth is interferred with is shown by one of their experiments in which fifteen mice were inoculated with the tumor tissue which had been exposed to the X-rays and in which 50 per cent of the rays were absorbed by the tumor tissue. Of these fifteen mice inoculated by this tumor tissue, there were no positive results and there were fifteen negatives. Of the control fourteen were positive and one negative. From these observations the author concludes that the rays hinder the subsequent growth of tumors when inoculated. With less absorption of rays there were more successful inoculations. In addition to the decrease in the number of successful inoculations there was a reduction in the rate of growth of the tumor even when inoculation was successful. Marie, Clunet, and Raulot-Lapointe,[3] in a study upon the heredity of the characters imposed upon tumors when they are exposed to the X-rays, selected a sarcoma of the mouse, a rapidly-growing tumor of a high degree of malignancy, with extremely stable histological features. A mouse bearing the tumor was exposed to a strong dose (30 H) of unfiltered X-rays, and five days later the animal was killed and portions of the tumor grafted into a number of mice; when this irradiated graft had grown to a suitable size, one was selected and submitted to the same dose of X-rays and five days later portions of it were again grafted into a number of mice. In this way the irradiated tumor was kept growing for twenty months and the new characters imposed upon it by the X-ray were thoroughly established. These new characters were found to consist mainly of (1) a reduction in the percentage of successful grafts, (2) a reduction in the malignancy of the tumor, (3) a slower rate of growth and certain histological features of which the following were the most important: (a) the presence of "giant" cells, some cells being as much as four or five times their original diameter, (b) atypical mitoses, (c) basophile "giant" cells having multiple nuclei. This shows a gradual reduction in the malignancy of the cells and their power to reproduce themselves, even under most favorable circumstances and even with the most malignant type of cells. This is additional experimental evidence in

[1] London: G. Bell & Sons, Ltd., 1915.

[2] Compt. rend. Acad. d. sc., 1909, Dec. 29.

[3] Bull. de l'Ass. franc. p l'etude du cancer, vol. iv, 4

favor of both ante-operative treatment and postoperative treatment.

Colwell and Russ also refer to the excellent researches made by Clunet and Raulot-Lapointe, which researches are reported in detail in Clunet's *Tumeurs Malignes* (1910). In these researches the author has adopted the following procedure: He treated the malignant condition with the X-rays and at various stages of the treatment obtained portions of the growth for histological study. As a result of observations of this nature upon nineteen cases of squamous cell carcinoma of malpighian type in the human subject, they state that before the ultimate disappearance of the growth, the cells pass through at least five successive phases which are characterized as follows: (1) the latent phase; (2) development of monstrous characters; (3) keratinization; (4) disintegration and phagocytosis; (5) formation of the connective-tissue scar.

1. *The latent phase* varies from six to fifteen days and during this time no cytological changes are to be seen. Its duration is rather shorter for carcinoma of the spinocellular type than for the basocellular type.

2. *The development of monstrous characters* is marked by: (a) an enlargement of all parts of the cells, which may be increased in diameter as much as two or three times; (b) an increased number of atypical mitoses; (c) the appearance of enlarged nuclei, markedly chromophile; and (d) the appearance within the cells of forms having a pseudoparasitic character.

3. *Keratinization* may be either disseminated, total or atypical. When disseminated, each cell undergoes keratinization independently of its neighbor, in contrast to those effects appearing to influence all cells alike. When atypical keratinization is observed, the protoplasm becomes granular, at first orangeophile and finally eosinophile; these granules gradually fuse together into one mass of keratin, and altogether they are probably similar in their chemical constitution to eleiden. They do not give the same color reactions as this substance.

4. *Disintegration and phagocytosis.* The disintegration of the degenerating cells appears to be caused mainly by the polynuclear cells and the fibroblasts of the stroma, which are in an active condition. Macrophages and plasma cells appear at a later stage and accumulate around the vessels, remaining in the vicinity long after the disappearance of the malignant cells.

5. *Formation of connective-tissue scar.* As a general rule this is not brought about by the formation of fibrous masses, but the tissues assume the structure of healthy skin, except for the absence of hair and of glands; the elastic fibers are also less numerous and more attenuated than they are normally. No neoplastic masses are to be found in these supple scars, which appear to be quite healthy. On the other hand, at a depth below the skin, cells may be found which have been acted upon by the X-rays but are not yet destroyed. Such cells remain in a latent condition and if the treatment is not continued they give rise to recurrences.

REPORT OF CASES

I shall make a report upon four cases of metastatic carcinoma of the spine, in all of which there was undoubted destructive disease due to the carcinoma and in which I have been able to demonstrate by roentgenograms not only the disease but the healing and healed process. Symptomatically the patients have shown either marked improvement or complete recovery.

CASE 1. Mrs. B., age 32, came to me September 19, 1913. She had been operated upon August 20, 1910, by John B. Deaver for carcinoma of the right breast (confirmed by pathological examination). The patient said that she had had in all four operations, for three successive recurrences. September 19, at the beginning of my treatment, the entire operative area on the right side was studded with nodules which were firmly adherent. These extended to the axilla, and in the right axilla there were masses from one-half to three-quarters of an inch in diameter firmly binding the tissues. There were large nodules in the supraclavicular region on the right side. The left breast contained a mass of tumor tissue with retraction of the nipple, with metastasis in the left axilla and in the left supraclavicular region. There were two small nodules in the left side of the scalp. About three inches of the left second rib and a small area in the third rib on the left side was destroyed and about an inch and a half of the right tenth rib, together with

disease of the eighth, ninth, and tenth dorsal vertebra, the fifth lumbar and the upper part of the sacrum. There were also distinct deposits in the lungs.

Ordinarily such an extensive distribution of disease would preclude even the thought of accomplishing any good results, but this patient had an unusual amount of determination to get well. Therefore, I decided to see what could be accomplished. All parts of the body, not including the extremities received treatment, and as much cross-firing was used as was possible. She received an enormous amount of treatment during a period of approximately eighteen months, and during this time 237 doses averaging about 15 X, or amounting to about 3,555 X, in all. As the result of this treatment she gained 17 pounds in weight, she gradually became able to look after her household duties and to do all her housework. All of the nodules on the right side of the chest disappeared as well as those in the right axilla and the right supraclavicular region. The mass in the left breast had shriveled, and while there remained considerable retraction of the nipple, the area felt like fibrous tissue and was freely movable. The metastasis in the left axilla and supraclavicular region had disappeared. The disease in the second rib had entirely healed. The disease in the vertebra showed evidence of healing. The disease in the third rib and the tenth rib had healed, and there was an increase in lime deposit which was evidence of healing in the fifth lumbar and in the sacrum. At the end of two and a half years she was free from symptoms excepting dyspnœa. During the succeeding six months she began to fail, the dyspnœa became more marked, and an examination of her chest on September 12, 1916, showed an extensive fibrous process throughout both lungs with retraction of the diaphragm upward, a general contraction of the lung area, and an examination of the extremities showed extensive metastatic carcinoma in all of the long bones. She died November 7, 1916.

This patient, therefore, was suffering undoubtedly from an extensive metastatic carcinoma at the time of her first visit. Over the areas treated by the roentgen-rays the disease healed. The patient regained a reasonable amount of health, was able to assume her household duties, and remained free from most of her symptoms during a period of at least two years. She probably had her life prolonged for a period of at least two years, during which time she lived in reasonable comfort. It illustrates, however, the statements made in the introduction to my paper that these cases are examples of a general carcinomatosis, and that ultimately we may expect the patient to die of carcinoma, even though there is a period of reasonable comfort and freedom from symptoms. It proves quite clearly the healing process of the roentgen-rays. It is interesting to note that the disease of the bones in the area treated showed no progression. It is also worthy of note that despite the fact that this patient received an enormous dosage over a period of 18 months covering the entire body and all the viscera, during which time the blood-making organs must have received much treatment, the patient continued to improve and the disease disappeared.

It seems to me to be a strong argument against the fact that we must depend upon a lymphocytosis for the healing of carcinoma or that prolonged X-ray exposure will reduce the lymphocyte and thus interfere with healing. It is likely that the discrepancy between Murphy's experimental work and this work upon the human subject is due to the fact that with small animals the entire body is exposed to the rays at once, while in clinical work we only expose a small portion of the body on any one day.

CASE 2. Mrs. P., age 34, was referred to me by L. H. S. DeWitt on November 5, 1915. On July 18, 1914, she had been operated upon for carcinoma of the right breast, by Lyman, of Grand Rapids, Michigan. Six months later the patient noticed recurrent nodules in the scar. One year after the first operation on the right breast Dr. DeWitt removed recurrent and metastatic nodules from the operative field, and also removed the left breast on account of carcinoma. At the time of my examination, November 5, 1915, she had two nodules in the right supraclavicular region, size three-fourths inches, disease in the upper mediastinum, disease of the head of the left humerus and in the head of the right humerus, disease in the left eighth rib, disease in the fifth dorsal vertebra, disease in the right glenoid cavity and the upper sacrum. She also had pains radiating down and along the right thigh, and tenderness over each of these points. At the end of a month there was some distinct improvement, her general health had improved, the metastatic nodules had definitely decreased in size, and there was some evidence of distinct healing process in the diseased areas of bone. This patient improved during the first three months; then conditions became rather stationary for two months more, and then the disease showed distinct evidence of progression and treatment was discontinued.

She died August 4, 1916, or approximately nine months after beginning treatment.

CASE 3. Mrs. M., age 52, was referred to me by Dr. VanLennop April 8, 1916. She had had her right breast amputated by Charles Noble in 1905, or 11 years previously and had no local symptoms or evidence of recurrence during these 11 years. In fact, she had no evidence of metastasis anywhere until about three months before coming to me, she fell down stairs injuring the back of her neck. This was followed by a neuritis, pains in the head, and a distinct swelling on the back of the neck. My examination showed almost complete destruction of the entire cervical vertebra, so that the patient's head seemed to be supported on a mass of soft tissue. The entire cervical vertebra were found decalcified and disorganized. There was also evidence of disease in the upper portion of the chest, and disease in the fourth, fifth, and the eighth dorsal vertebræ. She had received in all 165 doses during the first year. Since then she has received no treatment. At the end of six months, the vertebra which had been almost totally destroyed, had almost totally recalcified or healed. The patient was able to go about her usual affairs, was able to travel from place to place on rather long journeys, and was having a reasonable amount of comfort in life. During the fall of 1917, or about eighteen months after beginning treatment, I found her upon the boardwalk at Atlantic City, with a pulse of 120. In every other respect she seemed to be in a comfortable condition and free from symptoms. I ordered her placed in bed under the care of her family physician, and she has been under his care ever since. I received a telephone report from her son on September 3, 1918, at which time her heart condition had very much improved and none of the other symptoms referable to the spine had recurred.

This patient, therefore, showed a most pronounced healing effect of the diseased areas in the spine. This has been persistent, and so far as the carcinoma is concerned has been successful over a period of almost three years. It is entirely likely that sooner or later the disease will make itself manifest, and the patient will take the usual course as a result of general carcinomatosis.

CASE 4. Mrs. S. P., age 43, referred to me by C. C. McCormick, March 27, 1918. This patient had been operated upon in August, 1917, by Deaver, for carcinoma of the left breast, and received no postoperative X-ray treatment. In fact, none of these patients which I am reporting received any postoperative or ante-operative X-ray treatment. I do not mean by this that if she had received ante-operative or postoperative treatment she would have avoided the complications of metastatic disease that developed, for I believe that in most of these cases, if not all, the metastasis has taken place before the operation. In this case the operation took place in August, and in December McCormick wrote me telling me that she was having excruciating pain in the spine and extending down the legs and that she was bedfast. At that time the weather was bad, and I wrote to him that she undoubtedly had metastatic carcinoma of the spine, and since the patient was bedfast it was not right to take her away from home simply to die. I heard nothing further until March, when McCormick sent her down to the Medico-Chirurgical Hospital for examination and treatment. This was against my advice and against my better judgment, for I must confess that I do not like to treat these patients in which the disease has become extensive, even though occasionally one gets well or gets freedom from symptoms, for ultimately they die of the disease.

At my examination I found no evidence of local recurrence over the operative field, but I found disease with total destruction of the second lumbar vertebra, together with disease of the ninth dorsal vertebra. The disease of the second lumbar vertebra gave the usual angular deformity which is found when the body of the vertebra is destroyed. At the time of my examination and at the time of beginning treatment, she had been bedfast for fifteen weeks.

Under X-ray treatment, and with the assistance of a brace to give her spine support for her body, she was able to get out of bed. Gradually there was a recalcification of all of the diseased vertebra, and at present she can go about without any brace, though I have not given permission to do this. She can bend her spine in all directions; she has the appearance of perfect health; she has gained 30 pounds in weight and is able to do her washing and ironing and her general housework, and so far as symptoms act as a guide to us she has recovered completely.

She was demonstrated before the Philadelphia County Medical Society about a month ago, at which time I was able to show the healing process in the vertebra, and the free movement of the spine in all directions. Up until the middle of December this patient has received in all five courses of treatment, each course representing or requiring from 27 to 30 doses, making a total of 175 doses during a period of less than nine months. She is asked to return at the end of three months for inspection and observation. (Patient has returned April, 1919, and is still free from symptoms and is doing all of her housework.) She returned for examination exactly one year (March 17, 1919) after she had been sent on a stretcher. At this time she was free from all symptoms and the diseased vertebræ seemed to be healed (Fig. 1 and 2). She has been doing all her housework including her washing and ironing.

I treated this patient probably more extensively than the others, for I covered the entire spine and the entire body, not including the extremities. I have not included the

extremities in the treatment of these cases recorded, for I fear that there would be too much destructive effect upon the blood. This may be a mistake on my part, and we may find later that it is advisable to cover the entire body from the head to the extremities, for surely there has been no serious effect upon the blood in the cases that I have just reported. There has been nothing to suggest destructiveness to the blood. In these cases the patients only had a few blood examinations made, but there was nothing appearing in the blood except a moderate grade of anæmia. If there were much destructive effect upon the blood, the general health of these patients could not possibly improve as they have done.

TECHNIQUE

In the treatment of these cases, one must not only keep in mind the localized disease discoverable by the X-rays or by roentgenograms, but we must treat the case as one of a general carcinomatosis, and I think the next patient that I shall treat I will include the extremities and try to make the treatment a general one. In the four cases just treated, however, the exposures were confined to the body, not including the extremities, and the whole body was divided up into about thirty areas, crossfiring chiefly upon the spine, but of course reaching all other parts of the body as well. I used for each exposure, or for each dose, 8 minutes with 5 milliamperes, a 9-inch parallel spark gap, 5 millimeters of current at a distance of 8 inches, and the rays were filtered through 6 millimeters of glass or aluminum.

CONCLUSIONS

As a result of the studies made in these four cases and the treatment given, I believe that the following conclusions are justified:

1. The roentgen-rays when applied properly and in sufficient quantity upon deep-seated cancer tissue may be expected to destroy the cancer cell, and this cancer cell is replaced by healthy scar tissue, or fibrous tissue. When the disease is located in the soft tissues it is replaced by fibrous tissues, and when located in bone it heals by bone sclerosis.

2. As a result of this healing process, the patient is given the prolongation of life, and is made more comfortable.

3. One cannot expect the patient to make a complete, permanent recovery, for ultimately the disease is apt to show metastasis particularly in the areas not treated.

4. It is entirely likely that these metastatic carcinomata of the spine without other evidence of metastatic involvement have an unusual amount of natural resistance, and that this increased resistance on the part of the patient helps us greatly in the healing process. It seems to me likely that many of the patients, or most of the patients, die of visceral involvement, before there is time enough for symptomatic disease to develop in the spine, and so it is only in the more resistant cases that there is time enough for spinal metastasis.

5. With the clinical and microscopic proof of the destructive action on malignant tissue followed by a healing process, and with the experimental proof of a decrease in the malignancy of cancer tissue which has been exposed to the X-rays and a decrease in its capability of inoculation, we can recommend most strongly the use of deep roentgentherapy both as ante-operative treatment to be followed immediately by operation and then postoperative treatment, given after the proper interval, which should be four weeks after the ante-operative treatment.

THE TREATMENT OF UTERINE CANCER BY RADIUM

By HENRY H. JANEWAY, M.D., New York
Attending Surgeon and Head of the Radium Department, Memorial Hospital

DURING recent years an increasingly conservative attitude in the treatment of cancer of the cervix uteri has been adopted in many of the large clinics. Cancer of the cervix uteri, as regards its amenability to surgical treatment, contrasts strongly with cancer of the fundus. The latter can be successfully removed in a large percentage of cases without exposing an otherwise normal individual to a serious risk, while the mortality after an adequately planned operation for cancer of the cervix is high and the percentage of cures disappointingly low.

During the last five years of the past century, the low percentage of cures produced by vaginal hysterectomy was generally recognized, and the extended abdominal operation adopted by the more important operators. Wertheim has earned the credit of perfecting the details of this operation, having published his description in 1898. His operation represents the widest removal of carcinoma of the cervix. In experienced hands it has given a generally considered high percentage of cures, based on a freedom from recurrence of 3 to 5 years.

The percentage of cures in any series of cases is, however, dependent upon the favorable character of the cases selected for the operation, and the radical nature of the operation to which the patient is exposed. Thus we find that the most favorable statistics of cures accompanies, as a general rule, a low percentage of operability and a high primary mortality. In 1911, Jacobson collected statistics on the operability, primary mortality, and curability, as judged by the five-year standard, in 2765 cases of uterine cancer, reported by 130 operators.

Twenty-eight operators recorded percentages of operability. These varied from 5 per cent to 90 per cent: seven less than 25 per cent, ten between 25 and 50 per cent, six over 75 per cent.

With some exceptions, a definite relation, was found to exist between the percentage of operability and the mortality rate.

The primary mortality of the 2765 operations was 19.45 per cent. The mortality of many operators was below this: in the case of Jacobs, 6.37 per cent; Zweifel, 10.8 per cent; Kline, 12.8 per cent; Wertheim, 10 per cent (last two hundred cases); Doederlein, 14.3 per cent.

Many of the operators could not report final results, and with single exceptions there is no distinction between cancer of the fundus and cancer of the cervix. The following are the end-results reported:

Bergesio and Berrutti, of 20 patients operated on, 33 per cent were well one to four years afterward.

Bumm, of 56 patients, 30 per cent were well one year and over.

Dobbert, of 11 patients, 35 per cent were well one to four years afterward.

Doederlein, of 15 cancers of the fundus, 72.7 per cent were cured according to Winter's standard, and of 32 cancers of the cervix, 26.9 per cent were cured (same standard).

Mackenrodt, of 144 patients, 61.5 per cent, or 74 per cent of the survivors from operation, were well one and a half to six and a half years afterward.

Polosson, of 32 patients, 60 per cent were well five years later.

Reinecke, of 27 patients with cancer of the cervix, 20 survived the operation and 7, or 35 per cent, were well five years later.

In a subsequent report appearing in 1916, Jacobson includes more recent statistics and more definite information upon the permanent results of the radical abdominal operation for cancer of the cervix.

In the accompanying tables I have combined these results with those of additional operators, some of which are still more recent.

A number of these authors have given statistics on the results of operation for cancer of the cervix by the vaginal route, Table II.

TABLE I.—PERMANENT RESULTS of RADICAL ABDOMINAL OPERATION FOR CANCER

Name of Operator	Number Cases	Operability per cent	Operations	Mortality	Number Traced Cases. 3–5 Years	Cures
Bumm	100	60	60	12 (20%)	48 (5 yrs.)	24 (5 yrs.)
Hofmeier	...	.....	90	18 (20%)	32 (5 yrs.)	10 (5 yrs.)
Busse	75	78.95	59	15 (25.4%)	59 (5 yrs.)	19 (5 yrs.)
Bayer (Doederlein Clinic)	211	56	118	24 (20.3%)	94 (5 yrs.)	34 (5 yrs.)
Bovée	...	.....	36	9 (23.3%)	23 (5 yrs.)	8 (5 yrs.)
Taylor	40	68–70	28	3 (10.7%)	4 (3–5 yrs.)	0
Taussig	115	20	12 (more favorable cases)	1 (8%)		
			11 (more advanced)	8 (72%)		
Collected from surgeons West of the Mississippi	....	....	37	9	12 (5 yrs. including his own cases.)	5 (5 yrs.)
Collected from Mayo Clinic	...	.....	....	.....	12 (5 yrs.)	5 (5 yrs.)
Schottlaender and Kermauner (Rosthorn Clinic)	677	37.8 (256 cases)	256	46 (18%)	20 (5 yrs.) 22 (3 yrs.)	4 (5 yrs.) 14 (3 yrs.)
Faure	..	.....	24	2	24 (2–5 yrs.) (54%)	6 (8–14 yrs.) 13 (19mo.–6yrs.)
Cullen (John Hopkins Hospital)	...	.....	49	11 (23%)	26 (5 yrs.)	7 (26.9% 5 yrs.)
Neel (Dr. Kelly's Clinic)	263	57.7	136	28 (20.5%)	61 (5 yrs.)	14 (23% 5 yrs.)
Clark	...	.....	36	3 (8.33%)	30 (3-5 yrs.)	8 (26% 3-5 yrs.)
Weibel (Wertheim's Clinic)	1430	47.8	675	113 (16.6%)	372 10% first 100 cases 9% in last 175 cases	160 (43% 5 yrs.)
Sampson	...	.....	8	.....	8	4 (50% 5 yrs.)
Krinski	736	18.4	109	14 (13%)	53	11 (20.7% 3 yrs.)
Cobb	...	.....	34	5 (14.3%)	6	5 (83% 5 yrs.)
Waegeli	323	26.81	37	13	37	7 (18.91% 5 yrs.)
Wilson	59	15	79	14 (17.7%)	23	10 (43%)
Prochownick	536	61	123	25	112	16 (14.2% 5 yrs.)
Peterson	107	37.3	40	9 (22.5%)	40	18 (47.3%)

TABLE II.—RESULTS OF OPERATION BY VAGINAL ROUTE

Name of Operator	Number Cases	Operability per cent	Operations	Mortality	Number Cases Traced. 3–5 Years	Cures
Schauta	1305	38.1	654	39 (9.8%) of 395 cases total mortality 7.6%	350	5 Year Result 133 (17.4%)
Hofmeier	1909–1912	70.2				
	1913	48.5	57	3 (5.26%)	50	18 (37.5%)
Waegeli	...	.....	18	3 (16.66%)	18	3 (16.66%)
Prochownick	...	.....	200	22 (11.11%)	178	22 (11.11%)
Wilson	...	.....	57	1 (1.75%)	51	16 (31%)

TABLE III.—COMPARISON WITH RESULTS OF OPERATION ON FUNDUS

Name of Operator	Number Cases	Operability per cent	Operations	Mortality	Number Traced Cases	Cures
Mayer	....	.....	26	2 (.76%)	24	5 (5 yrs.)
Taussig, from Mayo Clinic	....	69.07	54	0 (0)	54	54 (5 yrs.)
Clark	....	.....	13	1 (7.7%)	13	7 (53.9% 4 to 6 yrs.)
Weibel, Wertheim Clinic	....	69.07	67	7 (10.5%)	....	37 (55.2 to 60% 5 yrs.)
Waegeli	17	76.47	13	2 (15.38%)	....	5 (38.46% 5 yrs.)
Prochownick	....	.....	60	7 (11.6%)	....	31 (50.1%)
Peterson	17	14.82	11	2 (18%)	....	9 (81.8%)

For comparison with the results of operation on carcinoma of the fundus of the uterus, Table III has been prepared.

A summary of these tables gives the following figures:

Carcinoma of the cervix removed by the radical abdominal operation: Of 5027 cases, 1720 or 34.21 per cent were operable. Of 1997 cases there was a mortality of 364, or 18.23 per cent. Of 1090 cases there were 386 cures (with few exceptions 5 years' standing) or 35.41 per cent of traced cases or 19.32 per cent of cases operated on, or less than 11.72 per cent of cases applying for treatment.

Carcinoma of the cervix removed by the vaginal method: Of 1305 cases, 654 or 58.1 per cent were operable (Schauta). Of 727 cases there was a mortality of 68 or 9.35 per cent. Of 647 cases, there were 192 cures (5 years' standing) or 29.67 per cent of traced cases or 17.74 per cent of cases operated on, or less than 11.72 per cent of cases applying for treatment.

Carcinoma of the fundus of the uterus: Operability, 76.47 or 97 per cent, average 86.73 per cent; mortality, 20 of 244 cases average 8.19 per cent; cures (5 years' standing) 148 of 242 operations, average 61.15 per cent or 53.03 per cent of cases applying for treatment.

If we accept Wertheim's conclusions that carcinoma of the cervix is twenty times as frequent as carcinoma of the fundus, it is possible to calculate on this basis the combined percentages for operability, mortality and curability of cancer of the uterus, i. e., including both cancer of the fundus and cancer of the cervix, by multiplying the percentages for carcinoma of the cervix by twenty, adding to the product the percentages for carcinoma of the fundus, and dividing by twenty-one.

Using this method the operability of carcinoma of the uterus is 37.61 per cent; the mortality is 17.74 per cent; the curability, based on the five-year standard for traced cases, is 36.63 per cent; for cases operated on, 21.31 per cent; for patients applying for treatment, 9.82 per cent.

A review of these tables indicates at first glance that the operative statistics, more certainly in the case of cancer of the fundus, but even for cancer of the cervix, are not unfavorable to this method of treatment. When, however, certain facts are considered in connection with these figures, the operative treatment of cancer of the cervix is far from satisfactory.

In the first place, while the immediate mortality in the most skillful hands is only 10 per cent, it is still 20 per cent in skilled hands, and in the hands of even Wertheim, during the period of the development of his operation, in his first one hundred cases, it was 30 per cent.

Such a high mortality restricts the usefulness of the operation to relatively few surgeons, entirely inadequate to meet the demands of the large number of patients having cervical cancer. Nor does this high mortality tell the whole story. It leaves out of consideration entirely, first, the necessity for restricting the operation to a small percentage of the most favorable cases, and second, the suffering entailed by the operation itself and its sequelæ. Such sequelæ followed von Rosthorn's operations in no less than 42 per cent, and included ureteral and bladder fistulæ, secondary necrosis of the bladder, injury to the rectum, fistulæ of the intestine, and in one case a division of the obturator nerve with permanent paralysis of the leg. Weibel reports 6 per cent of ureterovaginal fistulæ from the Wertheim Clinic.

Postoperative sequelæ, including suppuration of the abdominal incision, cystitis, peritonitis, ureteral fistulæ, vesical fistulæ, phlebitis, laceration of the rectum, pleurisy and rectovaginal fistulæ occurred in 22 cases of Clark's 36 patients, or in 73 per cent.

The majority of these postoperative sequelæ are, of course, temporary, but a sufficient number are permanent to constitute a real objection to the operative treatment of cancer of the cervix. These various unfavorable complications of the operation, the high mortality after an operation which is at all adequate, the by no means infrequent and unpleasant postoperative sequelæ, and finally, after a woman has faced all these risks, not to mention the discomfort of the operation itself, the rather small prospect that she will be permanently cured, that she will not be obliged to suffer a lingering and painful death, has caused many of the most prominent gynecologists to adopt a more conservative attitude toward the radical abdominal operation for cancer of the cervix.

This attitude is expressed in the concluding sentence of Schottlaender and Kramauner's book: "The time is not yet ripe for a review and criticism of the literature, many coworkers are yet necessary. . . . At present we can only say that we do not wish to underestimate or overestimate the importance of the abdominal operation. We are still at the

beginning of its development." At the time he wrote he considered it to be the only way to meet demands of the carcinomatous process.

Clark voices the same dissatisfaction with the operative treatment of cancer of the cervix. He states: "If an operation or other therapeutic procedure is to have a permanent place in our armamentarium it must be sufficiently easy to make it available, not for a few skilled specialists, but for the great body of surgeons working in every quarter of this and other countries. In these days of low mortality percentages, attending nearly all the major operations, no operation can possibly gain headway which combines with it a shockingly high mortality and a large number of distressing and disabling sequelæ.

"Further, while the continental surgeon, with his large and overcrowded clinics, may ignore the question of mortality in working out a principle, the American surgeon as well as the American layman is so temperamentally constituted that the one cannot and the other will not disregard a high primary death rate. The effect upon the lay mind, therefore, must be taken into consideration, for while one may have over 50 per cent ultimate cures, the effect upon the average intelligent citizen is abhorrent, if for this number of survivors there have been twenty-five deaths and for the other twenty-five a wretched existence attended by repulsive postoperative sequelæ followed by a painful and lingering death. It is possible that when we make a final summary of our combined experience we may have to accept the conclusion that a less radical operation, even though it save fewer cases, may be preferable when attended by a low surgical mortality and few or no operative sequelæ."

Peterson, I believe, sounds the same note. He states: "Unfortunately added experience has strengthened my belief that the extended operation for cancer of the cervix is an exceedingly dangerous operation, always attended by a high primary mortality. No one will be more glad to discard the radical abdominal method than will I, if I can be shown that more patients can be ultimately saved by less dangerous methods."

Since the above quoted expressions about the radical abdominal operation were written, another method of treatment of cancer of the uterus, its treatment by radium, has become prominent.

Wickham can be properly referred to as the father of the radium treatment of cancer. He began his work in 1906 and published the results of the treatment of a thousand cases of cancer in 1910 and 1913. Also as a pioneer, and working with Wickham, must be mentioned Dominici, who is responsible for the development of many technical improvements, particularly in the principles of filtration. Following these men many isolated reports have appeared: especially may be mentioned those by Caan in 1909, and Czerny and Caan in 1912, and Pinch in 1912, by Riehl, Ranzi, Schueller and Sparmann in 1913; in this country, Abbe, and finally the book by Paul Lazarus in 1913. It is just to give to Kroenig the credit of the most important introduction of the use of radioactivity in gynecology, but while he may have done the pioneer work in gynecology it was Doederlein's and Bumm's reports before the *Deutsche Gesellschaft fuer Gynaekologie*, at Halle, in May, 1913, and the papers by Chéron and Rubens-Duval, Schauta, Schindler, Scherer and Keley, and Latzko and Schueller, all in 1913, that furnished the great impetus to the treatment of cancer of the uterus by radium.

Doederlein reported one cure of an operable case of cancer of the cervix and excellent results in other cases. He presented microscopic sections proving the retrogression of cancer after the use of radium.

Bumm reported nine cases of apparent clinical cure of patients with advanced cancer of the cervix by the use of mesothorium and X-rays.

Chéron and Rubens-Duval reported 155 results, conservatively classified as improvements, of 158 patients with advanced cancer of the cervix. Forty-six of these improvements are probable cures. In two of the cases, both inoperable, the cure was proved, in one by autopsy, and in the other by histological section.

Schauta reported 11 clinical cures out of

16 patients with cancer of the cervix treated by radium and mesothorium. He believed that radium was the more effective of the two agents.

Schindler described some very favorable results in the treatment of cancer of the cervix by mesothorium and radium.

Scherer and Keley concluded that the treatment of 218 cases of cancer of the cervix by X-ray and radium gave 10.5 per cent greater freedom from recurrence than operation alone formerly gave.

Latzko and Schueller reported 5 clinical cures of 7 advanced cases of cancer of the uterus.

In the succeeding year still more encouraging results were published.

Bumm then recorded 108 cases of carcinoma of the cervix treated by radium. Of these only 5 were operable growths. Among them there were only 15 recurrences to date and a clinical cure had been produced in 10 inoperable growths.

Doederlein and von Suffert obtained a disappearance of all subjective and objective symptoms in 31 of 153 cases of cancer of the uterus, and 12 of the 31 were inoperable.

Kroenig recorded 254 cases of cancer of the uterus treated by X-ray and mesothorium. Sixty-four were treated prophylactically after operation and 150 entirely without operation. Nineteen have undoubtedly remained free from cancer. He concluded that in cases in which cancer was still localized to its primary site, the type of case usually termed operable, he was able to cause the complete disappearance of the cancer as far as could be recognized histologically. His longest cure, however, had been under observation for only two years. He had never been able to cure metastatic carcinoma, nor in those cases in which the disease had invaded the neighboring tissues, deep invasion, for instance, of the broad ligaments, though remarkable retrogressions and temporary cessations of growth had followed the treatment of the latter.

Dobbert made, in many respects, the most important contribution in 1914. The results of the treatment of 44 cases of cancer of the uterus, of which 31 were cancers of the cervix, 18 inoperable and 6 operable, were so good that they justify him in concluding that it is permissible to treat early operable cancer of the cervix by radium alone. In many cases when the invasion of the tissues around the site of origin was deep, an elimination of the growth might be expected. In still more advanced cases a condition temporarily approaching a cure could be obtained. In the very advanced cases he discouraged treatment.

Weinbrenner described eight most successful results in the treatment of 32 cases of genital carcinoma by mesothorium.

Allman reported results on 85 patients with cancer of the uterus, treated with mesothorium. At the time of his report 15 of these patients were free from symptoms. These 15 patients either had recurrent growths or had refused operation. Twenty other inoperable cases became operable.

Legneu and Chéron reported a patient with an extensive, entirely inoperable, cancer of the vagina treated with radium, and two and a half years after the completion of the period of treatment, the patient died after an operation for another trouble. An autopsy was obtained and the complete absence of cancer demonstrated. Other confirmatory reports, but of less definite character, have appeared from Morton, Dieffenbach, Foveau de Courmelles, Jacobs, Kroemer, Tate, Pozzi and Rouhier, Oertel, Seuffert and Klein.

In 1915 far more definite results were reported, many of which give information on the permanency of treatment by radium.

Doederlein now reports 12 patients with inoperable uterine cancer treated by radium and well at the time of his report, more than a year from the time the treatment was given. He definitely advocates the use of radiotherapy for operable uterine cancer.

Flatau states that since December, 1913, a period of one and a half years, he has not operated upon a single case of cancer of the cervix and has obtained a larger number of recoveries for an equal number of cases than he ever obtained by operation, though his mortality after operation was only 12 per cent.

Burrows reports that a disappearance of early cancer of the cervix and marked im-

provement in the more advanced lesions, after treatment by radium, is fairly constant.

Degrais reports a number of patients who had advanced cancer of the cervix treated by radium, who are in good health at the time of the report, four years after treatment.

Kelly and Burnam have made the most extensive use of radium in this country and have done so under very favorable conditions. They report the results on the treatment of 213 patients, 14 of whom were operable. Of these operable cases 4 were treated with radium alone and are all well, 2 for a period of two years and 2 for a period of one year after the treatment. The remaining 10 of the operable group were operated on first and afterward treated with radium. All were well at the time of the report at intervals of six months to three years after the treatment. The authors consider that these results are suggestive, when it is considered that after operation alone there is a recurrence in 75 per cent and in 60 per cent of the cases in the first year. One hundred and ninety-nine patients treated were inoperable at the time of the treatment; these included inoperable primary growths and inoperable recurrent cases. Fifty-three of this group are clinically cured and 109 markedly improved. Of 35 patients of this group, all primarily inoperable, 3 have remained well for four years, 2 for three years, and 17 for over one year. Eighteen primarily inoperable recurrent growths of this group are now clinically cured, 1 patient over six years, another over four years, 11 over two years, and 10 over one year.

In other words, 57 of 213 patients with cancer of the cervix, 4 operable and 53 inoperable, have been cured by radium; that is, all of the operable cases and 26 per cent of cases considered inoperable at the time of their treatment.

Baish reported that he has treated all cases of cancer of the uterus and vagina with mesothorium since February, 1914. At the time of his report he had treated 100 cases. The duration after treatment is from about twenty-one weeks to six months. He divides his patients into three groups. One group, 43 patients, were all inoperable, with definite parametrial infiltration. Many of these were benefited but only one clinically cured. In a second group of patients on the borderland of operability, 10, or 50 per cent, were clinically cured. The third group included 37 operable patients. Of these, 28, or 75 per cent, were clinically cured.

Adler reported a clinical cure in 9 inoperable cancers of the cervix, 2 inoperable cancers of the body of the uterus, and 1 of the vagina.

St. Clair recorded 2 cases in which radium was applied after incomplete operations for advanced cancer of the uterus. Fourteen months after the application in one case and a shorter interval in the other, both patients were, as far as could be ascertained, free from disease.

Fabre reported excellent results in 10 cases, the detailed histories of which were given.

Sir Thomas Oliver reported a very extensive recurrent cancer of the vagina apparently cured by a single application.

Von Graff, using the dosage recommended by Wertheim, and writing two years after a rather discouraging article by Wertheim on the radium treatment of uterine carcinoma, reported most encouraging results from the treatment of 102 cases of cancer of the uterus by radium. He concluded that radiumtherapy gives better results in the management of inoperable cases than any other method of treatment, and not a few cases thought inoperable have been so improved that the presence of carcinoma could no longer be demonstrated.

Miller also reported enthusiastically on the action of radium in advanced uterine cancer. He reported 6 cases, only one of which had gone one year from treatment. This patient presented, two years after operation, an extensive recurrence in the vault of the vagina. At the time of his report, one year after her treatment by radium, she was entirely free from symptoms.

Fueth and Ebeler reported results from the treatment of 56 patients with uterine cancer. Ten of these patients were operable and in each case retrogression had become complete, or nearly so, at the time of the report. Eleven other patients were treated prophylactically and six of the remaining number, all

inoperable, were clinically cured. Other papers appearing in 1915, supporting the same conclusions, are by Bergonie and Spéder, Abbe, Kolischer, Turner and Ransohoff.

Schmitz, in a paper appearing in 1916, recorded his results in the treatment of 80 cases of pelvic cancer. Of these he has obtained a clinical cure in 11 of 35 cases of inoperable cancer of the uterus, in 7 of 12 operable patients, and in 4 of 15 recurrent cases, making a total of 22 clinical cures of 62 patients, or 35.5 per cent. The post-treatment interval varied from four to twenty-four months. This report is very significant when we consider that 50 of his 62 patients, or 80 per cent, were not operable.

In the past year several important papers have appeared which more than confirm previous reports.

Maiolo has treated 50 patients, all of whom were inoperable or recurrent after hysterectomy. Eight of these patients were recently treated but of the remaining 42, 16 are anatomically and clinically cured for periods of one to two years.

Esquerido has treated 12 cases of uterine cancer; of these 3 were operable and all completely retrogressed. Of the remaining 7 inoperable patients, 3 were apparently cured.

Bailey reported 16 patients apparently free from disease, of 120 patients with uterine cancer treated with radium. Of these the post-treatment period had been two years in 1 case and one and a half years to two years in 4 cases, six months to one year in 8 cases, and one to six months in 3 cases.

Myers reported three excellent results, though recent, in 3 patients out of 5 whom he had treated. Labhardt, Klatz, and Heimann also reported favorable results.

Two other papers of particular importance have appeared during the past year.

The first of these is by Recasens, of Madrid. Recasens at first used radium only upon those cases which were too advanced for operation, or in which operation was contra-indicated, but his uniform success makes him no longer hesitate to treat early cancer of the cervix with radium. He states that if in inoperable cancer in which an actual extension to the parametrium exists, so that the possibility of a cure by operation can no longer be entertained, one can obtain a cure by radium in 60 per cent of the cases, it is only logical to believe that in early circumscribed cancer of the cervix a cure by radium is more certain. He contrasts the gravity of the Wertheim operation, with its primary mortality of 10 to 15 per cent in the hands of the best surgeons and its secondary mortality after the lapse of three to five years of 40 to 50 per cent, with the comparatively safe and simple procedure of treatment by radium with its "100 per cent of cures" in this stage. His belief that 100 per cent of the early cases are cured by radium is based on the fact that every one of 16 such cases, which he has treated, has undergone a complete retrogression and a number of these have already completed three years since the treatment was applied.

In addition to these results in operable cancer he has treated 182 inoperable cancers of the cervix. Forty-seven of these were treated in the year 1914, and of these 29 were well at the time of the report. In 1915 he treated 79 patients, of which number 45 were well at the time of the report. He has not been so fortunate in cancer of the body of the uterus. Of 16 cases of cancer of the body, only 8 were clinically cured and 6 have died, 2 being still under treatment. He concludes that 70 per cent of his inoperable cancers and 95 per cent of those cases in which the growth was still limited to its site of origin have been cured by radium. Fifty per cent of his cases of cancer of the fundus have been cured, but in this group he prefers operation, unless the woman is fat or possesses some other contra-indication to operation.

A second paper of equal importance is by Clark. He reports 100 patients with genital carcinoma treated by radium. Seventy-four of these were carcinoma of the cervix and 4 of the fundus. Fifty-five of these patients were alive and free from symptoms, two to thirty months after treatment, and in the case of 5 patients twenty-two to thirty months after treatment.

My own cases are few in number, being limited to patients referred to me for personal care. The majority of them are, from the

standpoint of operability, border-line cases. They are in consequence important from the standpoint of radiumtherapy, and I wish to put them on record, first, because I believe that the results obtained in them illustrate what can be obtained by the use of radium, in place of operation, in early cancer of the cervix, a preference in treatment, which is shared at present by very few surgeons; second, because I believe that there is an advantage in using the method of treatment which has been employed in these cases and which has been the outgrowth of my use of radium in other portions of the body.

CARCINOMA OF THE CERVIX—17 CASES, 12 CLINICALLY CURED TO DATE, 3⅛ YEARS TO 6 MONTHS AFTER TREATMENT.

CASE 1. Operable carcinoma of the cervix, clinically cured to date, 3⅛ years after treatment M. F., Hosp. No. 23027, age 48. On admission on March 25, 1916, the cervix was found to be enlarged and its vaginal surface ulcerated. The ulceration surrounded the external os, but did not reach the vaginal walls. The margins and base of the ulcer were raised, hard, and nodular. The body of the uterus was not enlarged. Microscopical examination revealed plexiform epidermoid cervical carcinoma. The cells showed slight swelling, much nuclear hyperchromatism and homogenization of the nuclei. At some points there was a rich exudation of lymphocytes and polymorphonuclear leucocytes which encroached on the masses of degenerating tumor cells. The patient's attention was first attracted to her disease by intermenstrual bleeding and rather profuse menstruation during the past two months.

Treatment. On March 25, 1916, 1 tube, containing 200 millicuries, in 1.5 millimeter rubber covered platinum, was left in the cervical canal for 16 hours; 2 tubes, containing 200 millicuries, in 1.5 millimeter rubber covered platinum, were left on vaginal surface of cervix for 16 hours. Examination on January 10, 1917, revealed no evidence of disease present. Examination May 6, 1918, showed absence of any evidence of disease. As the patient lived a long distance from New York, it was decided to give a prophylactic and mild treatment. One tube, containing 39.8 millicuries, in 1 millimeter rubber covered platinum, was placed in the vault of the vagina 6 hours.

Examination May 2, 1919, failed to discover any evidence of disease and a letter July 15, 1919, stated that the patient was in perfect health.

CASE 2. Carcinoma of cervix uteri on the borderland of operability, clinically cured to date 3 years after treatment. J. H., Hosp. No. 23521, age 52.

On admission, July 31, 1916, the cervix was found to be considerably enlarged and very hard. The body of the uterus did not feel enlarged. Extending over the dorsal portion of the cervix, about halfway to the reflexion of the mucous membrane to the vaginal wall, was an ulceration with hard base. Microscopical examination revealed plexiform epidermoid carcinoma. The patient has never considered herself strong and has been very nervous since an attack of nervous prostration 18 years ago. She has had three children, and one miscarriage 29 years ago. The oldest child is 27, youngest 16. The births were normal. Her menses have always been regular, every 3½ weeks, of 5 to 6 days' duration, with profuse flow. From April 15, 1916, to June 30, there was no menstruation. Then she was in bed with an intermittent flow for two weeks. After being up one week, she started to flow again, and has had intermittent moderate flow ever since.

Treatment. On July 3, 1916, 3 tubes, containing together 300 millicuries, in 1 millimeter rubber covered platinum, were placed one in the cevical canal, two against the vaginal surface of the cervix, for 12 hours. On September 20, 1916, the ulceration on the outside of the cervix was almost healed. The cervix was diminished in size and the uterus freely movable. One week following treatment, the patient had a hæmorrhage similar to the previous ones, the bleeding lasting one day. There was a gradual diminution of the discharge and there has been no discharge of blood since. At no time have there been any bladder or rectal symptoms. Her general health is steadily improving. Examined June 6, 1918, and found free from evidence of disease. Letter June 18, 1919, states that the patient is in perfect health.

CASE 3. Operable carcinoma of the cervix clinically cured to date, 1⅞ years after one application of radium. M. F., Hosp. No. 24748, age 42. The patient has had good health. Ten years ago she was operated upon for tubal pregnancy. Eleven years ago she was curetted for a miscarriage. She has been married 25 years. She is the mother of one child by instrumental delivery. The patient applied for treatment September 5, 1917. Six months before this the menses became irregular. Three months ago there was profuse bleeding at frequent intervals. Examination shows the posterior lip of the cervix to be the seat of an ulcer 2 by 3 centimeters. The whole cervix is enlarged and hard. The uterus is movable and normal in size. There is no infiltration in the broad ligaments. Microscopical examination reveals epidermoid carcinoma.

Treatment. On September 5, 1917, 3 tubes, containing 123 millicuries, in 0.5 millimeter silver, were arranged end-to-end in the uterocervical canal and left for 8 hours; also 3 tubes, containing 60 millicuries, in 0.5 millimeter silver, were applied against the cervix in dental modeling compound, for 8 hours. Healing followed in two months and the patient has been free from evidence of disease since.

Examined November, 1918, and found free from

evidence of disease. Letter dated July 18, 1919, states that her health is perfect.

CASE 4. Operable carcinoma of the cervix clinically cured to date, 1½ years after one treatment by radium. B. R. H., Hosp. No. 25129, age 74. The patient has had good health aside from sciatica and tonsillitis. The menses appeared at the age of 11, were scanty and regular, lasting from 5 to 6 days. Last date of menstruation at 54. She has had three children between 56 and 34 years ago. Labors were rather difficult with slight tears. The patient applied for treatment January 16, 1918. Four years before this she developed a partial prolapse of the uterus. Two weeks ago she sought treatment for the prolapse and was advised to wear a pessary. This was inserted and at the time of insertion a small ulcer was found on the cervix. She had felt no pain nor noticed any discharge from this. Examination showed a small ulcer on the anterior lip of the cervix about 2 centimeters from the external os. The ulcer measured 2 by 1.25 centimeters and was 0.5 centimeter deep. No deep infiltration was present. Microscopical examination revealed epithelioma of the cervix.

Treatment. On January 16, 1918, 2 unfiltered minute glass tubes, containing 8 millicuries, were embedded in the base of the ulcer, their period of decay giving an exposure of 1056 millicurie hours. On June 30, 1918, there was no evidence of the disease and no induration. On February 12, 1919, the patient was examined and found free from evidence of disease. Letter dated July 20, 1919, states that she is free from uterine symptoms.

CASE 5. Inoperable carcinoma of cervix clinically cured to date, 14 months after the first application of radium. G. S., Hosp. No. 25431, age 34. The patient has enjoyed very good health and has never been ill until the present trouble. The menses have been regular and normal. She has two children 13 and 14 years of age. The births were difficult and no instruments were used. The patient applied for treatment May 1, 1918. Three or 4 months before she first noticed bleeding from the vagina. This gradually increased up to the present time. Her physician at first advised operation but after having her under observation for about four weeks referred her to us for treatment. Examination showed the anterior lip of the cervix completely replaced by a large fungating papillary mass 5 centimeters in diameter completely filling the vault of the vagina; it bled on slightest touch and involved the mucous membrane as far as the vaginal wall. The uterus was movable. Microscopical examination revealed papillary plexiform epithelioma.

Treatment. On May 1, 1918, 3 tubes, containing together 101.9 millicuries, in 1 millimeter platinum, were applied for 15 hours, the tubes being arranged end-to-end in a rubber tube, placed in the uterocervical canal. On the same day, 7 unfiltered minute glass tubes, containing together 19.1 millicuries, were embedded in the tumor mass, their period of decay giving an exposure of 2521 millicurie hours. Following the treatment there was a quick retrogression of the tumor mass and retrogression appeared to be complete on August 19, 1918. Examination June 1, 1919: no evidence of disease; letter July 20, 1919, patient in perfect health.

CASE 6. Borderland but probably operable carcinoma of the cervix clinically cured to date, 14 months after one application of radium. N. H. D., Hosp. No. 25459, age 53. The patient has previously had good health. She has two children; the first an instrumental difficult delivery. The menses have always been regular and normal. She applied for treatment May 10, 1918. In March, 1917, she noticed an intermenstrual flow which gradually grew worse. She was curetted in April, 1918. Examination showed the vaginal surface of the cervix to be normal. The uterus was movable though together with the cervix was enlarged one-third the normal size. Microscopical examination revealed basal-cell carcinoma beginning within the cervical canal.

Treatment. On May 11, 1918, 5 unfiltered minute glass tubes, containing together 21.2 millicuries, were embedded in the tissue of the cervix, the decay period of which gives a dosage of 2798 millicurie hours; also, 3 tubes, 156 millicuries, in 1 millimeter platinum, were applied for 20 hours, the tubes being arranged end-to-end in the uterocervical canal. Examination September 30, 1918, showed no evidence of the disease. Examination June 4, 1919, showed no evidence of disease and letter dated July 20, 1919, states the patient's health is perfect.

CASE 7. Inoperable carcinoma of the cervix, clinically cured to date, 13 months after one treatment by radium. S. L., Hosp. No. 25563, age 48. The patient had scarlet fever when a child. She has had three children and one miscarriage. The first child was born 25 years ago, instrumental, difficult labor. The second child was born 12 years later and the third ten years after that. The menses have been regular and normal and there has been no unnatural discharge. The patient's general health has always been good. She applied for treatment June 15, 1918. Two months ago menstruation did not occur at the regular time but a profuse and irregular bleeding from the vagina appeared. There was no pain, no constipation and no bladder trouble. Examination showed the posterior lip of the cervix enlarged to twice the normal size, and covering its surface was a papillary growth infiltrating the underlying tissue. There was no infiltration of the broad ligaments. Microscopical examination revealed epithelioma of the cervix.

Treatment. On June 15, 1918, 11 unfiltered minute glass tubes, containing together 22.5 millicuries, were embedded in the cervical mass, the decay period giving a dosage of 2969 millicurie hours; also 3 tubes, containing together 137 millicuries, in 1 millimeter platinum, were applied for 27 hours, the tubes being arranged end-to-end in a rubber tube placed in the uterocervical canal.

March 1, 1919. Absolutely free from all local or general evidence of disease. There is no ulceration on the cervix. The cervix and uterus are normal in size and freely movable. Examined June 19, 1919, and found free from any evidence of disease.

CASE 8. Operable carcinoma of the cervix clinically cured to date, 12 months after one application of radium. M. McC., Hosp. No. 25657, age 40. The patient had scarlet fever followed by œdema of the legs for a period when a child. Otherwise her health has been good. The menses have been regular and normal in amount. She has no children. The patient applied for treatment July 16, 1918. Three months ago the patient noticed during an attack of constipation, some bleeding in the interval between menses. The flow increased and lasted from one to three days. She felt no pain and no discharge between periods of hæmorrhage. Examination showed the surface of the cervix to be destroyed by a hard rigid nodular ulcer. The ulcer extended posteriorly to the vaginal vault and bled easily. The uterus was normal in size although its movement was somewhat restricted. Definite induration in the broad ligaments could not be made out. Microscopical examination revealed epidermoid carcinoma.

Treatment. On July 16, 1918, 16 unfiltered minute glass tubes, containing together 29.2 millicuries, were embedded in the tumor mass, the period of decay giving a dosage of 3854 millicurie hours; also 3 tubes, containing together 100 millicuries, in 1 millimeter platinum, were applied for 20 hours, the tubes being arranged end-to-end in a rubber tube placed in the uterocervical canal. Examination May 29, 1919, showed no evidence of disease. Letter dated July 21, 1919, states that patient's health is perfect.

CASE 9. Inoperable carcinoma of the vagina, clinically cured to date, 11 months after one application of radium. C. S., Hosp. No. 25686, age 40. The patient has had infrequent epileptic attacks for 20 years. She had appendicitis last January. The menses have been painful. She has had four children; labors difficult. The patient applied for treatment July 25, 1918. Two years before she began to have slight hæmorrhage from the vagina and pain in the right groin. She has had constant backache and frequent micturition. Examination showed the vaginal wall immediately adjacent to the right side of the cervix covered with a neoplastic mass consisting of 2 nodules, one 2 centimeters in diameter, and the other 1 centimeter in diameter. Microscopic examination showed epithelioma.

Treatment. On July 27, 1918, 11 unfiltered minute glass tubes, containing together 25 millicuries, were embedded in the tumor mass, their period of decay giving a dosage of 3300 millicurie hours; also 3 tubes, containing together 281 millicuries, in 1 millimeter platinum, were applied for 11 hours, the tubes being arranged end-to-end in a rubber tube and placed in the uterocervical canal. September 25, 1918, the ulceration was entirely healed. March 1, 1919, retrogression still appears to be complete. July 10, 1919, examined and found free from all evidence of disease.

CASE 10. As regards operability, a borderland carcinoma of the cervix, previously cauterized, clinically cured by an application of radium. Later recurrence in the retrovaginal septum apparently successfully treated by a second application. M. S., Hosp. No. 25939, age 46. The patient has always been in good health, with no previous illness. Her menses have been normal as to time and duration. She has had two children, 24 and 22 years of age. The first birth was instrumental, the second normal. The patient applied for treatment October 22, 1918. Four months ago she began to flow continuously and was examined in May, 1918. Cauterization of the neck of the womb was suggested but was postponed until August, when she was told that a cancer had formed. Two weeks following cauterization, hæmorrhage appeared again and continued to the present time, with pain in the groin. Examination revealed the absence of the cervix, and in the center of the remaining portion of the canal an ulcerated area which did not feel very hard. The uterus was movable. Microscopic examination showed recurrent carcinoma of the uterus.

Treatment. On October 23, 1918, 2 tubes, containing together 117 millicuries, in 1 millimeter platinum, were applied for 21.5 hours, the tubes being arranged end-to-end within a rubber tube, placed in the uterocervical canal. November 20, 1918, two nodules have developed in the posterior vaginal wall. November 20, 1918, 2 tubes, containing together 5 millicuries, without filtration, were embedded within the nodules in the posterior vaginal septum. December 26, 1918, the nodules have been replaced by a broad indurated ridge, and on this day, 4 unfiltered minute glass tubes, containing together 9.3 millicuries were embedded in the mass in the postvaginal septum, giving a dosage of 1227 millicurie hours. February 12, 1919, the induration in the postvaginal wall has not disappeared and a small rectovaginal fistula has developed. July 17, 1919, the induration in the rectovaginal septum has disappeared and the fistula has closed and no evidence of disease remains.

CASE 11. Inoperable carcinoma of the cervix, clinically cured to date, 9 months after one treatment by radium. L. F., Hosp. No. 25958, age 40. The patient's previous health has been fair though she has never been robust. The menses have been regular, but inclined to be a little profuse, lasting 6 to 7 days. She has two children, 16 and 3 years of age. When the first child was born instruments were used and the patient sustained a severe laceration in the cervix uteri which was never repaired. Digestion is sensitive and the bowels regular. The patient applied for treatment October 30, 1918. Last April she first noticed the pain in her back. There was no change in the menses until June, when menstruation became more profuse and appeared every two weeks. In September there occurred three severe hæmorrhages 24 hours apart. Her

symptoms became gradually worse to date. Examination showed that the whole cervix was destroyed by an ulcerated infiltrating growth which was covered on its surface with slough and neoplastic nodules. The infiltration extended to the anterior and posterior vaginal walls and into the broad ligaments so that the normal mobility of the uterus was greatly reduced. Microscopical examination revealed epidermoid carcinoma.

Treatment. On October 30, 1918, 6 unfiltered minute glass tubes, containing together 21 millicuries, were embedded in the cervix, their period of decay giving a dosage of 2772 millicurie hours; also 3 tubes, containing 142 millicuries, with 1 millimeter platinum, were applied for 18 hours, the tubes being arranged tandem fashion, in the uterocervical canal. On November 6, 1918, 1 tube of 44 millicuries, in 1 millimeter platinum, was applied for 12 hours, the tube being placed within the cavity of the uterus. January 31, 1919, examination showed complete healing of the ulceration except for a small nodule the size of a pea to the right and behind the external os. The induration had disappeared to a large degree so that the cervix was not much harder than normal. The infiltration in the broad ligaments was still present, though less, and the movement of the uterus was still somewhat restricted. March 7, 1919, there was an entire disappearance of ulceration and induration. There was no evidence on examination that any malignant tissue remained though the cervix was deformed and its mobility limited as a result of its destruction, by the new-growth and the scarring following treatment.

CASE 12. Inoperable carcinoma of the vagina, clinically cured to date, 6 months after one application of radium. J. McC., Hosp. No. 26005, age 50. The patient had bladder trouble when 8 years of age, typhoid at 26 years. Menstruation had been normal. Eight years ago she began to have menorrhagia and metrorrhagia which persisted for a year until the patient took some local treatment which relieved her. On November 14, 1918, she applied for treatment. Five weeks ago she began to have pains throughout the lower abdomen, radiating down the thigh. Menstruation became scanty and an irregular and watery leucorrhœa, blood-tinged and offensive, developed. Examination showed the posterior right lateral and anterior vaginal walls to be covered with an ulcerated infiltrating mass covered by nodules which formed three rather well separated discrete masses. The total area of the mass was 6 by 9 centimeters. No glands were palpable in the groin. Microscopical examination showed epidermoid carcinoma of the vagina.

Treatment. On November 16, 1918, 8 unfiltered minute glass tubes, containing together 23 millicuries, were embedded in the tumor mass, giving a dosage of 3036 millicurie hours. On December 24, 1918, the entire lesion had disappeared except for a small fibrotic nodule in the posterior wall of the vagina just behind the introitus.

May 1, 1919, free from evidence of disease.

CASE 13. Inoperable carcinoma of the vagina and cervix improved for 8 months by one treatment of radium; subsequent applications ineffective. W. C., Hosp. No. 24452, age 56, had always had good health. The menses were regular and normal. She has had several children and three miscarriages. There were lacerations when the first child was born and ever since she has had a severe prolapse of the uterus. The patient applied for treatment May 28, 1917. About one year before this she began to feel pain in the left lower quadrant of the abdomen. It has increased in severity during the past four months and has been accompanied with a slight flow. Her general health has deteriorated. She has lost 30 pounds in the past year. Examination discloses an indurated ulcer covering an area of 6 square centimeters in the vault of the vagina and involving the cervix. Microscopical examination reveals papillary plexiform epidermoid carcinoma.

Treatment. On May 28, 1917, 4 tubes, containing together 37 millicuries, filtered through 0.5 millimeters silver, applied for 12 hours against surface of ulcer, in dental modeling compound. On October 1, 1917, there was no evidence of the disease. On March 19, 1918, a small recurrent ulcer was found in the vault of the vagina and 3 tubes, containing together 12.4 millicuries, without filtration, were embedded in the ulcer.

Following this treatment local improvement was reported, but the patient failed to return for observation until September 27, 1918, when an extension of the disease was observed. On October 1, 1918, 6 tubes, containing together 20 millicuries, without filtration, were embedded in the ulcerated area.

On March 1, 1919, a urinary fistula developed and around it an ulcer 3 centimeters in diameter, with indurated base and edges and considerable deep infiltration of the underlying tissue, characteristic of neoplastic tissue.

The poor result in this case is attributed probably to the inaccuracy and small dose of the first application, which in turn depended upon the extreme mobility of the uterus and looseness of the vaginal walls. A better result would have probably followed the embedding of emanation tubes in the ulcer.

CASE 14. Extensive carcinoma of the vagina temporarily improved by surface application of radium; recurrence in 4 months and gradual deterioration of the patient's condition. E. C., Hosp. No. 24467, age 60 years. Except for a severe attack of pneumonia two years ago, the patient's health has always been good. The menses were regular and normal. She has had nine children. The menopause occurred at the age of 40. The patient applied for treatment June 4, 1917. Two years before this she noticed a slight yellow discharge, and since that time she has lost 10 pounds in weight and has gradually lost her strength, and the discharge has increased in amount. Examination shows that the whole anterior wall of the vagina and adjacent portion of the cervix is the seat of an

indurated growth, the surface of which is covered by small neoplastic nodules. Microscopical examination reveals carcinoma of the vagina.

Treatment. On June 4, 1917, 24 tubes, containing together 360 millicuries, in 0.5 millimeter silver, were applied over the surface of the ulcer in dental modeling compound, for one hour. On July 17, 1917, the lesion was found to be reduced to one-half the original size. On the same day, 6 tubes, containing 198 millicuries, in 1 millimeter platinum, were applied over the surface of the ulcer in dental modeling compound for 4 hours. On August 17, 1917, retrogression seemed to be complete. On October 4, 1918, a fresh ulceration appeared on the anterior lip of the cervix, and on October 7, 1918, 3 tubes, containing together 256 millicuries, in 1 millimeter platinum, were applied for 11¾ hours in the uterocervical canal.

Following this treatment a uterovaginal or vesicovaginal fistula developed although continued retrogression of the disease took place. Her general health gradually deteriorated and the presence of internal metastases was feared. Report on March 11, 1919, states that she has not had any bleeding in the last 4 weeks. The urinary fistula is still present and she is very weak, but during the past 5 or 6 days she has been gaining in strength.

CASE 15. Inoperable carcinoma of the cervix clinically healed for almost a year by one application of radium; recurrence incompletely controlled by a second treatment. J. B., Hosp. No. 24695, age 44. The patient's previous health has been good. She has had two children, one miscarriage induced by instruments at 3 months, followed by infection which confined her to bed for 2 months. The patient applied for treatment August 15, 1917. Last November (1916) menstruation became profuse without pain. In March, 1917, an intermenstrual bleeding developed and soon became nearly constant and continued to time of applying for treatment, with perhaps a week's intermission, now and then, and still without pain. For the previous few weeks, an offensive leucorrhœa has been present and the bleeding has become less profuse. She has lost much strength and some flesh. Examination shows that the whole of the vaginal surface of the cervix is destroyed by an ulcerated growth, the surface of which is covered with numerous neoplastic papillary projections. The uterus itself is not much enlarged and its normal mobility does not appear to be restricted. Microscopical examination reveals carcinoma of the cervix.

Treatment. On August 16, 1917, 2 tubes, containing together 140 millicuries, in 1 millimeter platinum, were applied in a rubber covered tube in the cervical for 12 hours; also 13 tubes, containing together 325 millicuries filtered through 0.5 millimeter silver, were applied in dental modeling compound against the cervix, for 12 hours. On November 5, 1917, there was found on the anterior lip of the cervix a hard dense nodule but no definite evidence of neoplastic tissue was present (ulceration healed). December 17, 1917, showed the cervix still healed. The patient complained of painful defæcation. Examination revealed induration in the rectovaginal septum and some thickening of the broad ligaments. April 11, 1918, examination showed that the thickening of the rectovaginal septum had increased, producing stenosis of the rectum. On August 12, 1918, 8 unfiltered minute glass tubes, containing together 16 millicuries, were embedded in the mass in the rectovaginal septum, giving a dosage of 2112 millicurie hours. Following this treatment a rectovaginal fistula developed. To relieve this and the pain in the rectum, due to the recurrence, a colostomy was performed on September 25, 1918. This afforded the patient much relief from pain, but the infiltration of the tissues in the vault of the vagina remained and the patient's general condition steadily deteriorated.

June, 1919. During the past few months a remarkable improvement in the whole condition of the patient has developed; she left her bed, came to the office and was examined. Considerable diffuse induration still remained in the vault of the vagina but the patient's general condition aside from the presence of some pain and œdema of the legs was good.

CASE 16. Inoperable carcinoma of the cervix, clinically improved for 9 months after one application of radium. K. J. K., Hosp. No. 25551, age 54. The patient has enjoyed good health. Menstruation has been normal as to regularity and duration. She has had 8 children. One child is said to have weighed 20 pounds. This delivery was difficult and the cervix was torn. The patient applied for treatment on June 11, 1918. The menopause had occurred five years before. Seven months ago the patient noticed an irregularly appearing discharge from the uterus which 2 or 3 weeks ago became bloody. She has had slight backache for years, but she felt well and strong, and has had a good appetite and her bowels were regular. Examination showed extending laterally to the right from the cervical canal a deep ulcer with elevated nodules. The lesion was hard. The uterus was not enlarged and was movable. There was no induration of the broad ligaments. Microscopical examination revealed plexiform epithelioma.

Treatment. On June 12, 1918, 8 unfiltered minute glass tubes, containing together 20 millicuries, were embedded in the ulcer, giving a dosage of 2640 millicurie hours; also 3 tubes, containing together 131 millicuries, in 1 millimeter platinum, were applied for 28 hours, the tubes being arranged end-to-end and placed in the uterocervical canal. Following the treatment a rapid disappearance of the ulceration and induration took place.

March 15, 1919. No ulceration but an increase in the size of the cervix has developed with greater restriction of the mobility of the uterus, due to a diffuse infiltration of the base of the broad ligaments. A deep recurrence of the disease has taken place and the ultimate diagnosis is bad.

CASE 17. Very advanced carcinoma of the cervix clinically improved for a brief period after one treatment. E. W., Hosp. No. 26093, age 41. The patient's previous health had been very good. She has five children, births normal and she nursed each child. The menstrual history up to the time of the development of present trouble has been normal. Menstruation lasted five days and was regular, recurring each month. The patient applied for treatment December 17, 1918, In August, 1915, she began to bleed from the vagina between the menstrual periods. During the whole of 1916, 1917 and 1918, to the present time there has been a continuous flow of blood even more profuse than normal menstruation. She had influenza in November, 1918, since which time she has had pain in the back and left side. She has lost 15 pounds in weight and lately is somewhat constipated. Examination shows the vaginal surface of the cervix destroyed by an ulcerated hard mass continuous with a deep infiltration of the anterior vaginal wall and base of the broad ligaments. Mobility of the uterus is much restricted. Microscopical examination revealed carcinoma of the cervix.

Treatment. On December 17, 1918, 3 tubes, containing together 125 millicuries, in 1 millimeter platinum, were applied for 24½ hours, the tubes being arranged end-to-end in a rubber tube and placed in the uterocervical canal; also 9 tubes containing together 25 millicuries, were embedded in the tumor tissue.

March 1, 1919. Following the treatment she had one severe hæmorrhage. A progressive healing of the ulceration and retrogression of the disease has, however, taken place. At present she is free from pain and has had no bleeding for two months, but the anterior vaginal wall and the cervix are still infiltrated with hard tissue. There is some bladder tenderness. The advanced stage of this patient's disease at the time she applied for treatment precludes the possibility of a cure, but the temporary relief from the hæmorrhage and the pain meant everything to the patient.

RECURRENT CARCINOMA OF THE CERVIX—4 CASES: 2 CLINICALLY CURED, 16 AND 25 MONTHS AFTER TREATMENT, 1 IMPROVED.

CASE 1. Recurrent carcinoma of vaginal vault clinically cured to date, 25 months after first treatment by radium. A. D., Hosp. No. 24459, age 48. The patient's previous health had been good. The menses had been regular and normal. She has 11 children. The uterus was removed five years ago for carcinoma. The patient applied for treatment May 31, 1917. Three months before the patient suffered frequent micturition but felt no pain. Examination showed the vaginal vault densely infiltrated by a fixed mass which was ulcerated on its surface. Microscopical examination showed epidermoid carcinoma.

Treatment. On June 4, 1917, 3 tubes containing together 53 millicuries, in 2 millimeter lead, were applied for 8 hours, the tubes being placed against the tumor mass in a mold of dental modeling compound. On December 14, 1917, there was no evidence of disease. On January 12, 1918, there was some induration of the posterior wall in the vaginal vault. February 2, 1918, 2 unfiltered tubes containing together 9 millicuries, were embedded in the indurated nodule. May 3, 1918, and on July 7, 1919, there was no evidence of disease.

CASE 2. Recurrent carcinoma of the cervix in the vault of the vagina, clinically cured to date after 3 applications of radium. A. H., Hosp. No. 25271, age 50. The patient had always had good health. The menses were normal. She had two children, both normal deliveries. In May, 1916, an operation by cautery was performed upon the uterus. In April, 1917, a hysterectomy was done. Recently induration has appeared in the vault of the vagina. The patient applied for treatment March 9, 1918, for recurrence which was detected by her surgeon. She had no hæmorrhage or pain. Examination showed in the vault of the vagina an ulcer about 2.5 inches in diameter involving the mucosa of both the anterior and posterior vaginal walls, except at the center where it was covered with papillary nodules. Microscopical examination showed epidermoid carcinoma.

Treatment. On March 9, 1918, 3 unfiltered minute glass tubes, containing together 11 millicuries, were embedded in the lesion, giving a dosage of 1952 millicurie hours; May 25, 1918, 5 tubes, containing together 11.69 millicuries, were embedded in the lesion; October 23, 1918, 3 tubes, containing together 12.6 millicuries, were embedded in the lesion. On July 8, there was no evidence of disease, though a leakage of urine into the vagina had developed. The granulating area left after radium treatment has not entirely healed. October 9, there was practically a complete disappearance of all evidence of disease although some indurated nodules still remained in the walls of the vagina.

March 1, 1919. The patient is free from all ulceration and local evidence of carcinoma. The vesicovaginal or ureterovaginal fistula still persists. Her general health is good and aside from the fistula she is free from all discomfort. July 10, 1919, rectum and vagina free from any induration or evidence of cancer. The patient is perfectly comfortable. Her general health is good and the ureterovaginal fistula small and there is less leakage from it.

CASE 3. Recurrent carcinoma of the fundus, unsuccessfully treated. Death from metastases in 6 months. M. B., Hosp No. 23959, age 56. The patient had previously had good health. On December 3, 1916, she applied for treatment. In 1913 she noticed a discharge from the vagina which was not accompanied with pain. A microscopical specimen was taken and curettage performed, but the discharge which had become bloody, continued. In

August, 1915, she suffered a severe hæmorrhage. On October 12, 1915, a panhysterectomy was performed and since then she has never felt well. Microscopical examination revealed carcinoma of the uterus.

Treatment. On June 26, 1918, 5 unfiltered minute glass tubes, containing together 15 millicuries, were em edded in the nodules in the posterior vaginal walls, giving a dosage of 1980 millicurie hours. Present condition: There has been no further increase in the size of the nodules though the induration at their site has not completely disappeared. Her poor health since the panhysterectomy has not improved. The patient died apparently from internal metastases in the early part of January, 1919.

CASE 4. Recurrent carcinoma of the uterus, improved by treatment. E. W. W., Hosp. No. 25421, age 62. The patient had enjoyed good health until 5 years ago. In April, 1913, she noticed a prolapse of either the cervix or the walls of the vagina, accompanied with bleeding from the vagina. In May she was curetted and under a diagnosis of carcinoma the uterus was removed two weeks later. She was free from all symptoms for the next 4 years when there was a recurrence of the bleeding. For this she was treated in Los Angeles with radium. The patient applied for treatment April 29, 1918. Between April 3, 1917, and May 8, 1917, the patient received four treatments of 9 millicuries of radium, 1 tube, in 5 millimeters silver, and 1.3 millimeters of brass applied in the ulcer 14 and 16 hours each. Examination showed a small ulceration in the vault of the vagina. Microscopical examination showed recurrent carcinoma of the cervix.

Treatment. On April 29, 1918, 1 tube of 108.6 millicuries, in 1 millimeter platinum, was applied for 8 hours, the tube being covered by a rubber tube placed over the base of the ulcer. On July 17, 1918, the induration had practically disappeared but in the vault of the vagina was an ulcer covered with slough which was due to radium necrosis. Following this there was a progressive improvement in the patient's condition, the ulcer healing, the discharge diminishing and the tumor tissue being absent. January 17, 1919, all rectal and bladder irritation had ceased, but a blood-tinged discharge was still present. March 18, 1919, the ultimate prognosis in this case is probably bad though the presence of tumor at the present time cannot be proved. Her general health has been good since the radium treatment was begun.

CARCINOMA OF THE FUNDUS—4 CASES: 2 IMPROVED FOR PERIODS OF 2 YEARS; 2 CLINCALLY CURED, 14 AND 21 MONTHS AFTER TREATMENT

CASE 1. An early cancer of the fundus of the uterus. An apparent complete retrogression, with no evidence of recurrence for 2 years after treatment. A. S., Hosp. No. 23320, 70 years old. The patient had an early cancer of the body of the uterus with retrogression after one treatment. Examination on admission, June 5, 1914, shows the uterus slightly enlarged. There is a bloody discharge from the cervix. The cervix itself is not enlarged or ulcerated. The patient is fat and suffers some from dyspnœa on exertion. Her arteries are thickened and tortuous. Microscopical examination shows adenocarcinoma. Five weeks ago the patient noticed a blood discharge from the vagina and an uncomfortable bearing-down sensation. Three weeks ago she began to have pain in the back. These symptoms have gradually increased.

Treatment. Under nitrous oxide the uterus was curetted and the curettings showed on section adenocarcinoma. A tube containing a small quantity of radium was inserted into the uterus for 6 hours. July 31, 1914, a second treatment of 20 millicuries of radium was given for 8 hours. Following this treatment there has been no return of the menorrhagia nor any uterine symptoms whatever. The patient died in the summer of 1916 from apoplexy.

No examination was made later than a year after her treatment but the entire absence of uterine symptoms during the second year following treatment justified the conclusion that there was no local recurrence.

CASE 2. Advanced carcinoma of the fundus, clinically arrested for 2 years by radium treatment. C. C., Hosp. No. 21099, 77 years old. The patient was admitted to the New York Hospital, September 13, 1914. The uterus and cervix were curetted. Both were found to contain much soft tissue. Examination per rectum showed that the growth had invaded the anterior rectal wall. Microscopical examination showed adenocarcinoma of the cervix and uterus. The patient entered the Memorial Hospital September 25, 1914, at which time 25 millicuries of radium emanation were inserted in the cervix for 4 hours. She left the hospital much improved. She returned in about 2 months, and not much improvement was noted since the previous treatment. The cervix was found to be enlarged once and a half its normal size and was hard. There was more or less vaginal discharge. Some restriction of the normal mobility of the cervix was noted. The base of the broad ligament was much thickened.

Treatment. April 13, 1915, 1 tube, containing 50 millicuries, in 1 millimeter lead, covered with rubber, was applied in the cervical canal for 48 hours. Following this treatment there was vesical and rectal irritation, which subsided in the course of a few weeks. The patient then steadily improved and became free from all symptoms of her disease. Examination, February 13, 1917, revealed a small, shrunken cervix, free from all ulceration, and no evidence of disease involving the broad ligament. A few days before this examination she began to complain of a vague headache. About two weeks later she had pain and soreness in her right inguinal region, followed by tenderness over the right kidney

region. The urine was scanty and high colored, and upon examination showed a large quantity of pus cells and bacteria. She had some nausea and vomiting, but no rise of temperature. Her general condition deteriorated rapidly and she died on March 16, 1917.

Autopsy. An abscess was found surrounding the lower pole of the right kidney with extension to the wall of the renal pelvis and beginning purulent interstitial inflammation of the kidney. The uterus was reduced to a nodule of tissue 2 by 1 by 1.5 centimeters and was surrounded by adherent intestinal coils and fused with bladder wall. The vagina was shortened and thickened but smooth. On section the uterus was found infiltrated by alveoli of adenocarcinoma or malignant adenoma, in which the lining cells showed hydropic degeneration but the nuclei stained well. Mitoses could not be found. The muscle tissue was extensively fibrosed. The rectal wall was fibrosed but free from cancer. The bladder wall was infiltrated by scanty adenocarcinomatous alveoli over an area of 2 centimeters in diameter, but the mucosa was intact.

In this case we can at least say that a clinical cure of two years' standing was obtained in an advanced cancer of the fundus of the uterus.

CASE 3. Operable carcinoma of the fundus, clinically cured to date, 21 months after one radium treatment. C. M. B., Hosp. No. 24889, age 40. The patient had had the usual diseases of childhood. In 1910, she became ill with a severe attack of dysentery and precordial pain. The trouble was later diagnosed as acute dilatation of the heart. The patient was kept in bed for over a year on a very rigid diet and since this treatment has only had a mild attack of precordial pain and tachycardia. The patient applied for treatment October 25, 1917. In 1915, profuse menstruation developed and first attracted the patient's attention to her present condition. The bleeding became more profuse and caused severe anæmia. Since August, 1916, she has had four very severe hæmorrhages. Examination reveals a normal cervix, with a somewhat enlarged, movable uterus. Microscopical examination of a section made of the curettings obtained October 26, 1917, at which time the patient also received a radium treatment, showed adenocarcinoma.

Treatment. On October 26, 1917, 2 tubes, containing together 156 millicuries, enclosed in 1 millimeter platinum and 1.5 millimeters rubber, were applied for 8 hours in the cavity of the uterus. Following this treatment the hæmorrhage ceased and there was progressive improvement of the patient's condition. A letter received from the patient, March 24, 1919, says that she feels better than she has for the past 8 years. Menstruation has entirely ceased but the patient leads a sedentary life because of her cardiac condition, and to this she attributes the abdominal tympanities accompanied with occasional pain in the stomach and abdomen. July 22, 1919, in telephone message patient states she is free from discharge and as well as previously.

CASE 4. Operable carcinoma of the fundus, clinically cured to date, 14 months after one radium treatment. A. W., Hosp. No. 25442, age 62. The patient has enjoyed good health. The menses have been regular and normal. She has five children. Births have been normal. The menopause occurred 10 years ago. The patient applied for treatment in October, 1917, at which time a slight bleeding occurred. She received some local treatment, but the bleeding recurred in April and she submitted to curettage. Microscopic examination of the curettings showed adenocarcinoma.

Treatment. May 6, 1918, 2 tubes, containing together 83 millicuries, in 1 millimeter platinum, were applied for 15 hours, the tubes being arranged end-to-end in a rubber tube placed in the uterocervical canal. Advice from the patient March 1, 1919, states that she is well and free from uterine symptoms. July 11, 1919, examination of patient shows an absence of all evidence of disease, the uterus being practically normal.

CARCINOMA OF THE EXTERNAL GENITALS—5 CASES: 3 CLINICALLY CURED TO DATE, 21 TO 16 MONTHS AFTER TREATMENT WAS BEGUN; 1 IMPROVED, 1 UNIMPROVED

CASE 1. Primary carcinoma of the labium minor and urethra, clinically cured to date, 21 months after the first radium treatment. A. W. L., Hosp. No. 24830, age 69. The patient had never been seriously ill. She applied for treatment October 8, 1917. For over a year she had noticed a very slight vaginal discharge, accompanied by very little discomfort. Several years previously a small caruncle was removed from the urethra. Several months ago the patient noticed a small mass which she thought to be another caruncle. The mass was about the size of a pea and caused some burning during micturition. Examination revealed upon the right border of the introitus a flat, slightly raised tumor 2 centimeters long and 2 centimeters wide. Its base and edge were hard and covered with neoplastic nodules, and extended upward into the vagina to just within the vaginal orifice. Microscopic examination showed epidermoid carcinoma.

Treatment. On October 9, 1917, 9 tubes, containing together 248 millicuries, in 1 millimeter silver, were applied for 1¾ hours, the tubes being applied over the ulcer and held in place in a mold of dental modeling compound. On January 8, 1917, the induration had practically disappeared except for two small tumor-like ulcers 0.5 centimeters in diameter. June 1, 1918, retrogression was almost complete except for a slight induration. On June 1, 9.2 millicuries in 4 unfiltered minute glass tubes were embedded in the tumor mass, giving a dose of 1214 millicurie hours. Following this treatment the patient continued to improve, and she failed to return for subsequent treatment until February 25, 1919, when an indurated nodule was discovered in the site of the original lesion. This was apparently

a submucous recurrence and measured about 2 centimeters in diameter. February 26, 1919, 5 unfiltered minute glass tubes, containing together 16 millicuries, were embedded in the substance of the tumor mass, giving a dosage of 2112 millicurie hours. March 12, 1919, the nodule had almost disappeared. July 1, 1910, examined and absolutely no evidence of disease present.

CASE 2. Primary carcinoma of the clitoris, clinically cured to date, 19 months after one radium treatment. E. S., Hosp. No. 25160, age 60. The patient has enjoyed good health. She applied for treatment January 1, 1918. Her present illness began in September, 1917, when she first noticed burning and a small swelling in the neighborhood of the right labium and clitoris. This swelling increased slightly in size to the present time and the burning sensation had become more disagreeable. Examination revealed in the anterior right labium minor two large nodules, 2 centimeters in diameter. These were ulcerated on the surface and the two bases were broad and hard with deep infiltration of the underlying tissues. The anterior nodule involved the clitoris. Microscopical examination showed epidermoid carcinoma.

Treatment. January 1, 1918, 6 tubes, containing together 303.7 millicuries, in 0.5 millimeter silver, were applied for 1.5 hours, the tubes being placed against the surface of the lesion, embedded in dental modeling compound; also 3 tubes, containing together 9.3 millicuries, without filtration, were embedded in the tumor mass, giving a dosage of 1327 millicurie hours. Following the treatment there was a gradual disappearance of the induration. On September 30, 1918, there was no evidence of the disease. July 11, 1919, there was still no evidence of disease.

CASE 3. Advanced carcinoma of labium minor. Death from erysipelas following treatment by buried emanation. I. S. A., Hosp. No. 25164, age 65. The patient had scarlet fever and diphtheria when a child. She has never been very strong. During the past few years she has been troubled with almost constant diarrhœa. The patient applied for treatment January 29, 1918. One year ago she noticed a small ulcer on the right labium, unaccompanied with pain, but causing itching and burning. Last September a discharge developed which has gradually increased to the present time. Examination showed upon the right labium an ulcer 2.5 centimeters in diameter. There was also a large nodule in the right inguinal region 1 centimeter in diameter. Microscopical examination showed epidermoid carcinoma.

Treatment. January 29, 1918, 2 unfiltered minute glass tubes, containing together 17.1 millicuries, were embedded in the base of the ulcer, giving a dosage of 2240 millicurie hours. Following the treatment the patient developed erysipelas, from which she died March 8, 1918. At the time of death there was an almost complete disappearance of the induration at the primary site of the disease.

CASE 4. Primary carcinoma of the urethral meatus and labium minor, clinically cured to date, by 3 radium treatments. Duration, 16 months after the first treatment. J. H., Hosp. No. 25283, age 42. The patient had diphtheria when 12 years old. A large fibroid was removed from the uterus 8 years ago. The patient applied for treatment March 12, 1918. Three months ago she had noticed first a slight vaginal discharge which at first was intermittent and later continuous. Two months before application for treatment she noticed a soreness in the labia minora. Six weeks ago micturition became painful and these symptoms have increased slightly to the present time. Examination shows surrounding the urethral meatus and destroying the anterior two-thirds of the right labium minor an ulcer with an indurated base and papillary surface 2.5 centimeters in diameter. The anterior border involves the clitoris. The induration of its base is deep seated and extends 2 centimeters upward into the superior vaginal wall. Microscopical examination showed epidermoid carcinoma.

Treatment. On March 14, 1918, 5 unfiltered minute glass tubes, containing together 11.3 millicuries, were embedded in the base of the ulcer, giving a dosage of 1491 millicurie hours; also 5 tubes, containing together 152.3 millicuries, in 0.5 millimeter silver were applied for 3 hours against the ulcer, in dental modeling compound. On July 2, 1918, 12 unfiltered minute glass tubes, containing together 15 millicuries, were embedded in the residual induration, giving a dosage of 1980 millicurie hours. Following the first two treatments the patient gradually improved until July, when the ulceration was almost healed but there remained considerable induration. Following the treatment in July, improvement continued until January 2, 1919, when all evidence of the disease had disappeared with the exception of a small pea-sized nodule of doubtful significance in the posterior right labium. To insure safety this was treated on January 16, 1919, 2 unfiltered minute glass tubes, containing together 7.8 millicuries, being embedded beneath the nodule, giving a dosage of 1129 millicurie hours. March 1, 1919, nodule undergoing rapid disappearance. July 7, 1919, no evidence of disease.

CASE 5. Advanced carcinoma of labia majora, held in check for 1 year by two radium treatments. M. E. H., Hosp. No. 25434, age 57. The patient has enjoyed good health except for the usual diseases of childhood. She applied for treatment May 3, 1918. One year ago she noticed itching of the vulva. This increased in severity and later was replaced by burning and severe irritation during micturition. Several months ago an ulcer was located in the labia which was treated with local application. Examination of the left labium major shows a large elevated, flattened ulcer. It measures 5 to 6 centimeters in diameter. The base is hard and covered with neoplastic nodules. There are enlarged glands palpable in the groin. Microscopical examination shows epidermoid carcinoma.

Treatment. May 4, 1918, 5 unfiltered minute glass tubes, containing together 11.8 millicuries, were embedded in the tumor mass, giving a dosage of 1557 millicurie hours; also 9 tubes, containing together 587.2 millicuries, filtered through 5 millimeters silver, were applied for 2 hours, the tubes being placed over the lesion in dental modeling compound. Following this treatment there has been progressive improvement. The patient, however, was examined at irregular intervals due to the distance at which she lived from New York. March 12, 1919, the original lesion has been replaced with cicatrix depressed in the center and of a somewhat leathery consistency in the periphery. Two pea-sized hard nodules of suspicious character are present in this peripheral portion. The inguinal glands are not enlarged. The patient is practically free from discomfort and although an ultimate cure is not expected on account of the size of the original lesion, the patient up to the present time has a clinical cure of nearly a year's standing and is still improving. Renewed activity of growth became manifest in April, 1919, and on April 16, 1919, a second treatment of 2300 millicurie hours by buried emanation was administered.

These cases, 30 in number, have a post-therapeutic period, varying from 3⅓ years to 6 months, and comprise 17 carcinomata of the cervix, 4 recurrent carcinomata of the cervix, 4 carcinomata of the fundus, and 5 carcinomata of the vulva (labia minora and clitoris).

Of the 17 carcinomata of the cervix, the post-therapeutic period in one is 3⅓ years, in another 3 years, and in a third 1¾ years. Nine of the remaining cases, all treated within the past year, have undergone the same continuous retrogression after a single treatment, as the first three cases treated with the longer post-therapeutic period.

Five of the 17 carcinomata of the cervix have recurred after the first treatment and are again under treatment. The fact, however, that they have developed a recurrence is deemed a very unfavorable factor in their ultimate prognosis. In 2 of these cases a large portion of the vaginal wall was involved. Two others had bad symptoms of bleeding for many months before the radium treatment. The remaining case had a very advanced lesion, has been treated recently and is still under observation

All 4 of the cases which developed a recurrence showed a primary retrogression which was complete for a short period in 2 cases and became almost complete in the other two. In all four of these cases the recurrence or renewed growth developed within 4 months from the time of the first treatment. The fifth case is still improving but was so extensive at the time of treatment that a cure is not expected.

Of the 4 patients with carcinoma of the fundus, one, an old lady, died of intercurrent disease, two years after the radium treatment. She never had any return of her uterine symptoms. A second patient remained in perfect health for 2 years from the time of her first treatment. The third patient, treated 1½ years ago and the fourth patient, treated within the past year, are still free from symptoms.

Of the 4 recurrent cases, one patient treated first two years ago, is still free from any evidence of disease. Another, first treated a year ago, is free from evidence of disease. A third, treated 2 years ago, has recently required another treatment and at present shows symptoms of metastasis in the upper pelvic glands. The fourth case was not improved.

The greatest interest centers around the 5 cases of carcinoma of the vulva. In one of these the lesion involved the clitoris and in the other 4 the labia minora, the urethral orifice, and anterior vaginal wall. In 2 of these cases a clinically complete retrogression followed treatment. One of these patients developed a recurrence which is at present satisfactorily retrogressing after a second treatment. The other has remained free from evidence of disease for 15 months since her treatment. In the third patient, wholly inoperable, the retrogression is at present so complete that a cure is expected.

A fourth patient with a very advanced lesion is still improving and under treatment. While none of these five patients can be classed as cures it must be remembered that in all but one progressive improvement of over a year's standing and amounting to a fairly complete retrogression followed the radium treatment, a result which is better than that usually following operation for this form of cancer.

Of equal importance with the consideration

of the results of the treatment of uterine cancer with radium is a consideration of the methods by which these results have been obtained.

The majority of radium therapeutists in gynecology use single tubes. These are inserted inside the uterus or within the cervical canal, or against the vaginal surface of the cervix, or in several of these locations, at the same or at alternate treatments.

The dosage generally used has been heavy, sufficient to cause extensive sloughing, and entirely too heavy for almost any other region of the body. Bumm, for instance, recommends a total dosage of 8700 milligram hours to 15,000 milligram hours.

Chéron and Rubens Duval use the Dominici tubes, wrapped in gauze and placed in the vagina, and give 48 to 7200 milligram hours, repeating this treatment when they deem it necessary.

Schauta recommends the use of 50 milligrams filtered by 2 millimeters of lead, applied for five days, or 6000 milligram hours, and the repetition of this dose in ten days' time, giving thus virtually 12,000 milligram hours. In eleven cases he has had two severe hæmorrhages, one vesicovaginal fistula and one rectovaginal fistula.

Schindler uses as small a quantity of radium carbonate as corresponding to 27 milligrams of pure radium bromide. This is enclosed in a lead capsule 1.3 millimeters thick and placed within the vagina for days.

Scherer and Keley filter through 1.3 millimeters lead and use a total dosage of 3820 milligram hours.

Latzo and Schueler use the Dominici tubes of 0.5 millimeter silver covered with 1½ to 3 millimeter lead and a dosage of 15,300 to 16,800 milligram hours.

Doederlein gives 12,000 to 14,000 milligram hours, in divided doses in the course of 1 to 2 months.

Dobbert recommends 2400 milligram hours repeated every third day until 6000 to 7000 milligram hours have been given. He filters through gold and brass, rarely through lead.

Weinbrenner gives 8004 to 13,680 milligram hours and filters through silver.

Allman uses 150 to 200 milligrams of radium bromide for 24 hours, 3600 to 4800 milligram hours, repeating the treatment at intervals of two to four weeks. He uses nickel plated brass filters. He had severe symptoms in a number of patients from overdosage.

Burrows uses a strong application within the cervix, 50 to 60 millicuries of emanation filtered through 1 millimeter of silver and simultaneously two to three needles containing emanation thrust into the broad ligaments and posterior lip of the cervix, left in place 24 to 48 hours.

This treatment is further reinforced by the application of varnish-plates over the abdomen.

Kelly and Burnam have not yet described their technique.

St. Clair has successfully used as small a quantity as 10 milligrams of radium, applied within the cervix and uterus, six times at intervals of 6 to 8 days, for 24 hours each time, a total dosage of only 1440 milligram hours.

Sir Thomas Oliver obtained his excellent result from a single application of 24 hours' duration, of a single tube of emanation, containing probably 50 to 100 milligrams of emanation, in other words 1200 to 2400 milligram hours.

Von Graff reports severe effects from overexposure. He used at first 250 milligrams and later 40 milligrams for 24 to 48 hours. This is repeated once or twice at intervals of 2 to 3 days and of a second series of exposures given in two to three weeks. This probably represents 1000 to 2000 milligram hours at each exposure. He reports no bad effects from his later weaker dosage.

Schmitz, who has furnished a very favorable report, uses 50 milligrams radium element for 40 to 48 hours, giving as a rule two treatments, 12 to 36 hours apart. This amounts to 2000 to 2400 milligram hours. The radium is filtered through brass 1.2 millimeters thick. It is divided into two tubes arranged tandem. These are applied within the cervix, and reinforced by crossfire from a second application of two tubes, arranged side by side, and applied against the cervix. Thus the total milligram hours amounts to 4000 to 4800

milligram hours. This treatment is repeated in three weeks time but only if there is no great change. If improvement occurs the consideration of further treatment is postponed for another three weeks. Schmitz also cites experiments on cutaneous nodules of breast cancer which demonstrated that the γ-rays from 50 milligrams of radium element, applied for 12 hours (600 milligram hours) will destroy carcinomatous tissue 1 centimeter distant.

Clark describes his dosage only in connection with uterine myomata and here refers to 50 milligrams for 24 hours or 1200 milligram hours, as a large dose for the interior of the uterus. We assume that he uses a similar dosage for cancer.

Bailey formerly used a dosage of 3000 millicuries in the vagina applied to the cervix and filtered through 1 millimeter platinum. A tube of 600 millicurie hours is applied within the cervix, and 600 millicurie hours directed toward each parametrium. In addition to this, 3000 millicurie hours is applied over the abdomen in three places, over the center of the abdomen, and over each inguinal region. He now uses 2000 millicurie hours in one platinum tube placed in the cervical canal and 3000 millicurie hours from his bomb directed in fractions of 1000 millicurie hours each in three different directions against the cervix and a total of 18,000 millicurie hours applied externally at a distance of 4 centimeters from the spine over six different areas in a circle around the pelvis, i. e., 3000 millicurie hours over each area.

Recasens uses 70 milligrams of radium for 20 to 24 hours. He has used 130 milligrams for as long as four hours. In other words 1400 to 1680, or even 6240 milligram hours. This treatment is repeated after an interval of 8 days and again a third time after another 8 days. It is again repeated after 20 days and sometimes altogether six or eight applications are made, two months elapsing between the later applications.

Of these methods of treatment that of Schmitz corresponds more closely than the others with our own. We believe it important in the treatment, at least of cervical cancer, to crossfire from within the cervical canal and from the surface of the ulcer. Moreover we cannot understand the heavy dosage recommended by many of those whom we have quoted.

In our experience one treatment appears to be all that is required in many cases. The two cases which we here report having gone the longest time, one of them 3 years and 4 months and the other 3 years, have each received only one treatment.

For the average favorable case 6000 millicurie hours in one treatment may be all that is necessary, while a repetition of this treatment at too soon an interval, or increasing it, may cause the patient much unnecessary discomfort, or produce fistulæ.

The radium should be divided equally among six tubes. These tubes may be the regular Dominici tubes of 0.5 millimeter silver, but we prefer tubes of 1 millimeter platinum. The tubes which we use are 2 centimeters long, with a central radium containing portion 1¼ centimeters long and walls 1 millimeter thick. Such tubes have the filtering power of 2 millimeters of lead and are less bulky.

While the Dominici tube filters out practically all the α- and β-rays it does not filter out many of the soft γ-rays. One millimeter of platinum or 2 millimeters of lead filters out also the softer γ-rays. One millimeter of platinum or 2 millimeters of lead permits, therefore, the use of a much larger percentage of deeply penetrating radiations, which are far more homogeneous. Radiations from radium filtered in this manner must be used for a longer period and so used will exert a far more distant effect and a much better defined selective action.

For cancer of both the fundus and the cervix we advise the use of three of these tubes containing 150 milligrams of radium and inserted in the uterocervical canal, arranged end-to-end in a long rubber tube. For cancer of the cervix three additional tubes are placed against the cervical ulcer. The tubes placed against the cervical ulcer should be distributed evenly over its surface and the best method of retaining them in such a position, is by embedding them within a mold of the cervical ulcer and vagina made of

dental modeling compound. This compound is the preparation which dentists use for obtaining impressions of the teeth. Placed in hot water it becomes soft, like putty, and in this condition may be inserted into the vagina. Left there it cools to the body temperature, at which it becomes hard enough to retain its shape. It forms, therefore, a perfect mold of the interior of the vagina and may be easily removed and reinserted and when reinserted it always finds the same position in the vagina. Upon this mold is an impression of the cervical ulcer. The three radium tubes may be embedded at equal distances from each other within the area of the mold which shows the impression made by the cervical ulceration. When the mold then is reinserted into the vagina, these tubes come into accurate apposition and are evenly distributed over the ulcer. This mold serves an additional function in holding the vaginal walls and with them the bladder and rectum away from the cervix and the radium lying against it, and thus protects these organs from burning. If the radium is so placed that it comes into dangerous proximity to the bladder and rectum a piece of lead may be embedded behind it, in the opposite surface of the mold, thus still more completely insuring the protection of the bladder and rectum. An absolute protection of the bladder and rectum and overhanging vaginal walls is not desirable. Schottlaender and Kermauner have shown that in a definite percentage of cases of cancer of the cervix, metastatic extensions are already present in the vaginal walls, at some distance from the cervix. It is, therefore, not desirable to protect the vagina too strongly when applying radium to the cervix.

Some protection is advantageous because in its absence disagreeable bladder and rectal tenesmus and discomfort from burning in the vagina can follow strong applications to the cervix. The cervix itself is practically insensitive to strong treatment. I have found that the separation of the vaginal walls by the dental molds is sufficient and yet allows a desirable amount of radiation of the vagina.

Special provision for directing strong radiations against the broad ligaments with a comparative neglect of the anterior and posterior parametrium is probably unsafe as compared to a uniform radiation of all the parametrial tissue.

Schottlaender and Kermauner have shown that the regions in front and behind the cervix are frequently involved by the direct extensions of the growth.

The distribution of the radiations should, therefore, be made as diffuse as possible around the cervical ulcer as a center.

Attempts to supplement the internal treatment of uterine cancer for the purpose of more effectively reaching extensions into the uterus, broad ligaments and lymph nodes by the application of heavily filtered radium over the abdomen are of undetermined value.

Bailey in his excellent work uses such crossfiring though the abdomen in all his cases. Levine and Koernig have good results from crossfiring by X-ray radiations. My own experience in the treatment of epidermoid cancer in the deep cervical lymphatics, where the effects of the treatment can be followed with greater accuracy, and in a few advanced cases of uterine cancer confirms the experience of these men and indicates that a definite additional impression is made upon the extensions of uterine cancer by crossfiring through the abdomen. We are not, therefore, justified in neglecting this accessory means of treating uterine cancer. Nevertheless its importance must not be overrated, for there are some objections to its use. When the crossfiring is given by radium, and this is the agent of choice because its radiations are more penetrating than the X-ray radiations, large quantities are needed. These quantities are only available in a few stations. Moreover, their use prevents the treatment of other patients. The X-rays, which will be further improved in the future, are a more practical means of crossfiring uterine cancer through the abdomen, but even the use of these rays seriously complicates the treatment for many patients.

Until, therefore, the indications for the use of crossfiring through the abdomen are more thoroughly understood, until we know how much more it accomplishes than palliative improvement, a failure to be able to give it

should not be regarded as a contra-indication to the treatment of uterine cancer by local applications alone.

It must not be forgotten that uterine cancer when still limited to the regions of its primary appearance is curable by these local applications alone. None of the cases, for instance, in this report has received any other treatment.

The dosage which I have found safe and efficient in cancer of the cervix, the radium being distributed as above described, is 6000 millicurie hours, i. e., divided into 3000 millicurie hours within the uterus and 3000 millicurie hours against the cervix, in other words, it is recommended that the radium should be divided into 6 tubes for the treatment of cervical cancer and, if each tube contains 50 milligrams, 3 of the tubes arranged end-to-end are placed in the uterocervical canal for 20 hours and the other 3 against the cervical ulcer for the same length of time.

One of these treatments may cause a complete retrogression, and a repetition of the treatment may not be necessary. In our experience the best results have been obtained when a repetition of the treatment was not necessary.

Theoretically this is so and should prove so practically for just as the success of the removal of the cancer by operation is best when the removal is complete, so every effort should be made completely to destroy carcinoma of the uterus by one blow, when it is first seen, and, therefore, most limited around the site of origin. If repetitions of the treatment become necessary a long interval should elapse and much care used in making the second treatment, as the tissues will not bear the same dose a second time so well.

We believe there is some advantage in cervical cancer in the use of emanation enclosed within minute glass tubes, which are embedded in the tumor mass instead of the surface application of radium.

We recommend the use of 20 to 30 or 40 millicuries of emanation according to the size of the tumor treated, distributed as evenly as possible throughout the tumor. Bagg has shown that 1 millicurie will produce a general necrotic effect through a sphere of tissue surrounding the tube for a distance of 1 centimeter. It is important, therefore, that the amount of emanation in each tube should be reduced to a minimum consistent with the avoidance of objectionable trauma, dependent on the introduction of too many tubes. The dose from 20 to 40 millicuries of emanation is 2640 to 5280 millicurie hours.

From our experience with unfiltered emanation in other regions of the body, the intense shower of β- and soft γ radiations, having it is true, a more limited radius of effectual activity, produces a more complete destruction of cancer than the more penetrating γ radiations alone. These are more accurately applied and distribute the radiations more evenly through the cancer tissue, and subject the patient to less inconvenience than any other method of treatment.

A review of the cases reported in this paper does not, of course, prove that radium is, at the present time, the method of choice for treating primary carcinoma of the fundus or cervix uteri. Taken, however, in conjunction with the other reports in the literature above quoted, it suggests that in only a few years there will be ample proof that radium is the method of choice in the treatment of cancer of the uterus, at least of that most frequent form of cancer of the uterus and most difficult to manage by operation, cancer of the cervix.

The presentation of the evidence furnished by this report may, therefore, be premature in so far as operable cancer of the uterus is concerned. It is, however, conclusive for cancer of doubtful operability, but so strong for operable cancer of the cervix that in the light of the other published observations the treatment of early cancer of the cervix by radium is, at the present time, justified.

More than this, it suggests that it is unjust to the women of the country to wait 3 to 5 years longer before the widespread distribution of radium throughout the country is planned for.

Each medical center in the country should plan to own sufficient radium to care for at least the uterine cancers of its district. While it is desirable that sufficient radium should be purchased by each of these centers to permit

the use of emanation and this supply be placed under the care of a trained man who can properly become responsible for its use by the physicians of the district concerned, yet for the treatment of uterine cancer alone the use of emanation is not an absolute necessity. The treatment used in the vast majority of the cases thus far reported, and in the author's earlier cases, those having remained well the longest, has not been by emanation and is quite within the power of the private owner of radium. This treatment has proved efficient. In the later cases the author has preferred the combination of filtered radium emanation with the embedding in the cervical ulceration of unfiltered emanation tubes. The advantages offered by this combination at least in treatment of uterine cancer, may be sacrificed when the use of radium itself is only possible. These facts are important because they make practical the treatment of cancer of the cervix generally throughout the country.

When we consider that at a conservative estimate 8000 to 9000 women die of carcinoma of the uterus each year in the United States[1] and that a search, as elaborate as can be made through the published reports, including as these reports do, circular letters sent out by Cullen and Taussig, through the South and West in the United States, finds only 61 women operated upon five years prior to 1916, who have been cured of carcinoma of the cervix uteri, can any consideration justify the postponement of the general use of radium in the treatment of uterine carcinoma? While, of course, more than 61 women up to 5 years ago have been cured by operation of cancer of the cervix, in this country, yet it is safe to say that this number indicates what a drop in the bucket the operative treatment of cancer of the cervix uteri is toward meeting the real demands of this malady upon the medical profession. But granting that the radical abdominal operation could cure 100 per cent of the operable patients of cancer of the cervix, applying for treatment, there are not in the country a sufficient number of capable surgeons to do the required work.

Contrasting with this record the record which radium has already made, however immature this record may be, the fact that it has produced cures of two to four years' standing in cases too extensive for operation; that it has produced cures of three years' standing and over, in a larger percentage of early cases than operation has produced, one author claiming for it in this stage 100 per cent of cures; the fact that treatment by it in no way interferes with the patient's routine life and subjects her life to no risk; the fact that it is a remedy capable of being used by any one possessing the simplest gynecological training, after receiving certain easily acquired technical instruction; contrasting these facts with the operative records, is not the time ripe to urge each county medical society to make the effort to place a supply of radium in its district? Three hundred milligrams are sufficient for the treatment of one case every 24 hours. Less may be successfully used but if so the treatments must be longer and the number of cases treated less.

Aside from the relief in advanced cases, can there be any doubt that, if such a plan be carried out, more cases of cancer of the uterus would be cured than are now saved by operation and a knowledge of this fact soon go further in inducing women to seek help in an early stage than are at present induced by the attractions of a radical abdominal operation?

The strong argument for the radical abdominal operation has always been the fact that it is the only method by which lymphatic metastases may successfully be removed, and yet few of the cases with such metastases have ever been cured by operation.

Weibel, of the Wertheim clinic, states that 25 per cent of all cases upon which he operated had cancerous glands and nearly all died of recurrences. In his whole series only ten such cases remained well five years.

Sampson reports one case cured in which a metastasis was found in the lymphatic gland.

Clark states that, if the higher pelvic lymphatic systems are the seat of metastases, it is scarcely possible for the widest and most

[1] The 17th annual report of the mortality statistics of the Bureau of Census for 1916 states that there were: 58,600 deaths from cancer that year, 8,898 deaths or 15.2% were from cancer of the female generative organs, divided as follows: ovary and fallopian tube, 544; uterus, 8,085; vagina and vulva, 218; unclassified, 51.

painstaking dissection to completely eradicate it.

None of Busse's cases in which the presence of carcinoma in the lymphatics was demonstrated ultimately recovered.

Hofmeier saved no case in which the removed glands contained carcinoma.

Schottlaender and Kermauner state on page 456 of their book on carcinoma of the uterus, based on the 256 operations of von Rosthorn's clinic, that in the later years not much importance was attached to the necessity of removal of glands, and in the review which the author gave this book, he found no case which ultimately recovered in which the glands removed contained carcinoma.

We may conclude then that only isolated cures can be obtained by any method when the cancer has left its primary site, so that any error made in neglecting attention to the higher pelvic lymphatic glands is more than offset by higher mortality accompanying attempts to remove them.

Cancer of the cervix, in probably the majority of cases, displays a strong disposition to remain localized for a long period. Zweifel, for instance, records 23 operations for recurrent cancer of the cervix, of which 7 were free from further recurrence seven and a half years.

If cases with cancerous lymphatics can be cured, it is far better to attempt to do so by opening the abdomen after treating the primary disease with radium and embedding emanation in the enlarged glands. We have evidence in our work with radium in the mouth that its effect extends to the first set of regional lymphatics.

From the therapeutic standpoint, cancer of the uterus must be regarded as a local disease, and the most practical method of handling the disease at its site of origin must be adopted.

Our present evidence indicates that radium destroys the disease at this site to a greater distance than the knife is capable of removing it, and does this with no risk or inconvenience to the patient and only a small tax on the skill of the surgeon. Every effort should, therefore, be made to secure its general use throughout the country.

BIBLIOGRAPHY

ABBE, R. Uterine fibroids, menorrhagia and radium. Med. Rec., 1915, lxxxvii, 379–381.

ADLER. Ueber Radiumbehandlung bei Gebaermutter Krebs. Monatschr. f. Geburts. u. Gynaek., xli, 145.

ALLMANN. Zur nicht operativen Karzinombehandlung. Strahlentherapie, 1914, iv, 625.

BAILEY, H. Radium in uterine cancer. Surg., Gynec. & Obst., 1918, xxvi, 6, 625.

BAISCH, K. Erfolge der Mesothoriumbehandlung bei 100 Uteruskarzinomen. Muenchen. med. Wchnschr., 1915, lxii, 1670.

BERGONIE, J., and SPÉDER, L. Le traitément du cancer utérin inopérable par la rontgen thérapie et la radium thérapie combinées. Arch. d'élect. méd., 1915, xxiii, 140–148.

BOVÉE, J. W. Statistics of radical operation for cancer of cervix uteri. Am. J. Obst., 1912, lxvi, 380.

BUMM. Ueber die Erfolge der Roentgen und Mesothorium Behandlung beim Uteruskarcinom. Deutsche Gesellsch. f. Gynaek., Halle, 1913.

BUMM, E. Weitere Erfolgerungen ueber Karcinombestrahlung. Berl. klin. Wchnschr., 1914, lix, 193.

BUMM. F. Ztschr. f. Krebsforsch., 1910, x, 105.

BURROWS, S. Radium treatment of cancer of the cervix of the uterus. Am. J. Surg., 1915, xxix, 296.

BUSSE, W. V. Dauer-resultate bei dem Operation des Uteruskarcinoma nach den abdominalen Methoden. Monatschr. f. Geburtsch. u. Gynaek., 1912, xxxv, 35.

CHÉRON, H., and RUBENS-DUVAL, H. Ueber den Wert der Radiumtherapie in der Behandlung der uterinen und vaginalen Krebse. Fortschr. a. d. Geb. d. Roentgenstrahl., 1913, xxi, 229.

CLARK, John G. The therapeutic use of radium in gynecology. Surg., Gynec. & Obst., 1918, xxvi, 619.

Idem. The radical abdominal operation for cancer of the uterus. Surg., Gynec. & Obst., 1913, xvi, 255.

COBB, F. Cancer of the uterus with special reference to the possibilities of cure by a radical abdominal operation Boston M. & S. J., 1914, clxxi, 731.

CULLEN, THOMAS S. Radical operation for cancer of the uterus. Surg., Gynec. & Obst., 1913, xvi, 265.

DEGRAIS, P. Radium thérapie du cancer du col de l'utérus. Ann. de gynéc. et d'obst., 1915, xi, 609; Surg., Gynec. & Obst., xxii, 3, 298.

DENT. Gesellsch. f. Gynaek., Halle, 1913, May.

DIEFFENBACH, W. H. Radium in the treatment of cancer. Med. Rec., 1913, lxxiv, 1068–1072.

DOBBERT, T. Ergebnisse der Behandlung des Gebaermutter-Krebses mit Radium. St. Petersb. m. Ztschr., 1914, xxxix, 97.

DOEDERLEIN. Roentgen-Mesothorium Behandlung bei Myom und Carcinom des Uterus. Surg., Gynec. & Obst., 1913, xvii, 428.

DOEDERLEIN, A., and SEUFFERT, E. Unsere weiteren Erfahrungen mit der Mesothorium Behandlung des Carcinoms. Muenchen. med. Wchnschr., 1914, lxi, 225.

Idem. Zentralbl. f. Gynaek., 1915, xxxix, 12, 177.

ESQUERIDO. Resultadas de la applicatión del radium en el cancer del utero. Therapia, Barcelona, 1917, ix, 681.

FABRE. Les indications de la radium thérapie dans le traitément du cancer de l'utérus. Ann. de gynéc. et d'obst., 1915, xi, 620.

FAURE, J. L. Traitément du cancer du col de l'utérus par l'hystérectomie abdominale. Bull. et mém. Soc. de chir. de Par., 1913, xxxix, 1061.

FLATAU, S. Duerfen wir operable Uterus-Karcinome ausschliesslich Bestrahlen? Zentralbl. f. Gynaek., xxxix, 611.

FOVEAU DE COURMELLES (Paris). 1st part, le rayons X; 2nd part, le radium en gynécologie. XXVII Internat. Congr. Med., Lond., 1913, viii, 79–96.

FUETH, H., and EBELER, F. Radiotherapy of cancer. Zentralbl. f. Gynaek., xxxix, No. 14, 217.

GRAFE, E. Ueber die bisherigen Erfahrungen mit Radium und Roentgenstrahlen bei der Krebsbehandlung. Strahlentherapie, 1915, v, 627.

HEIMANN, F. Le traitément radio et radium thérapique des cancers utérins. Arch. d'électricité méd., 1917, xxv, 530.

HOFMEIER, M. Zur operative Behandlung der Carcinoma colli uteri. Ztschr. f. Geburtsh. u. Gynaek., 1911, lxix, 453.

JACOBS. Roentgen and radium therapy in gynecology. Discussion. XXVII Internat. Cong. Med., Sect. VIII (2), Obst. & Gynæc., Lond., 1913, 198.

KEENE. Radiotherapie in Gynecology. Penn. M. J., 1917, xx, 469.

KELLY, H. A., and BURNAM, C. F. Radium in the treatment of carcinomata of the cervix uteri and vagina. J. Am. M. Ass., 1915, lxv, 1874.

KLEIN, G. Roentgen and radium therapy in gynæcology, discussion. XXVII International Cong., Lond., 1913, viii, (2), 200.

KOLISCHER, G. Modern radiotherapy in malignant tumors and localized tuberculosis. Lancet-Clin., 1915, lxxiv, 287–289.

KOLTZ, R. Economie d'énergie rayonnante dans le traitément du cancer inopérable. Arch. d'électricité méd., 1917, xxv, 430.

KRINSKI, L. A. Die operative Behandlung des Portio Carcinoms. Verhandl. d. l. russ. Krebskong. St. Petersb., 1914; by Zentralbl. f. d. ges. Gynaek., Geburtsh. u. d. Grenzgeb.

KROEMER (Greifswald). Roentgen and radium therapy in gynecology. XXVII Internat. Cong. Med., Lond., 1913, viii (2), 193-195.

KROENIG. Roentgen rays, radium and mesothorium in the treatment of uterine fibroids and malignant tumors. Am. J. Obst., 1914, lxix, 205.

LABHARDT, A. Corres.-Bl. f. schweiz. Aerzte, 1917, xlvii, 961–973.

LEGNEU and CHÉRON. Guérison par radium therapie d'un cancer ureterovaginal inopérable. J. d'urol., 1914, v, 3.

MAIOLO, G. C. Osservazioni cliniche sulla radium terapie ai 50 casi di carcinoma uterino. Ann. di ostet. e ginec., Milano, 1917, xli, 99.

MEYERS. Radium in the treatment of cancer of the uterus. Iowa St. M. J., 1918, viii, 296.

MILLER, C. J. Radium in the treatment of carcinoma of the cervix. Surg., Gynec. & Obst., 1916, xxii, 437.

MORTON, WM. J. Radium for the treatment of cancer and lupus. Med. Rec., 1907, lxxii, 760–766.

NEEL, J. CRAIG. Results after the Wertheim operation for carcinoma of the cervix of the uterus. Surg., Gynec. & Obst., 1913, xvi, 293.

OERTEL, T. E. The present status of radium; report of cases treated. J. M. Ass. Georgia, 1914, 180–181.

OLIVER, SIR THOMAS. Radium and its efficiency in cancer of the vulva. Lancet. 1915, l, Feb. 6, 272.

PETERSEN, REUBEN. The extended operation of carcinoma of the uterus. Surg., Gynec. & Obst., 1916, xxiii, 237; Tr. Am. Gynec. Soc., 1916.

POZZI, S., and ROUHIER, G. De l'hystérectomie restreinte complétée par la radium thérapie dans les cancers de l'utérus. Rev. gynéc. et chir. abdom., 1914–1915, xxiii, 209–264.

PROCHOWNICK, L. Behandlung und Statistik des Gebaermutter Krebses. Zentralbl. f. Gynaek., 1915, xxxix, 627.

RANSOHOFF, J. L. Radium in the treatment of cancer of the uterus. Lancet-Clin., 1915, lxxiv, 289.

SAMPSON, JOHN A. Results of the radical abdominal operation for cancer of the uterine cervix. Surg., Gynec. & Obst., 1913, xvi, 304.

SCHAUTA. Monatschr. f. Geburtsh. u. Gynaek, 1912, xxxvi.

Idem. Radium and Mesothorium bei Carcinoma cervicis. Monatschr. f. Geburtsh. u. Gynaek., 1913, xxxviii, 503.

SCHERER, A., and KELEY, B. Ueber die Behandlung des. Uterus Krebses mit Roentgen und Radiumstrahlen. Versamml. deutsche Naturforsch. f. Aerzte, Wien., 1913.

SCHINDLER, O. Erfahrungen ueber Radium und Mesothoriumtherapie maligner Tumoren. Wien. klin. Wchnschr., 1913, xxvi, 1413, 1463.

SCHMITZ, H. An additional contribution to the therapeutic value of radium in pelvic cancer. Surg., Gynec. & Obst., 1916, xxiii, 191.

Idem. The action of radium on cancer of the pelvic organs; a clinical and histological study. J. Am. M. Ass., 1915, lxv, 1879.

SCHOTTLAENDER and KERMAUNER. Zur Kenntniss des Uterus Karzinoms. Berlin: S. Karger, 1912.

SEUFFERT, E. VON. L'état actuel, les problèmes et les limites du traitément radio et radium thérapique du cancer. Arch. d'électricité méd., 1914, xxii, 552-571, 610-625.

ST. CLAIR, R. Radium treatment of malignant tumors. West M. Times, 1915, xxxv, 89,

TATE, W. Discussion—Roentgen and radium therapy in gynecology. XXVII Internat. Cong. Med., Lond., 1913, viii (2) 199.

TAUSSIG, FRED. The prognosis for radical abdominal operation for uterine cancer. Surg., Gynec. & Obst., 1912, xv, 147.

TAYLOR, HOWARD. Operation for carcinoma of the cervix uteri. Surg., Gynec. & Obst., 1912, xv, 141.

THALER. Zur erweiterten vaginalen Karzin zu Operation. Zentralbl. f. Gynaek., 1915, xxxix, No. 41.

TURNER, DAWSON. Report on the radium treatment at the Royal Infirmary, Edinburgh, during the year 1915.

WECKOWSKI. Radium in Cancer. Berl. klin. Wchnschr., li, No. 31, 1453.

WEIBEL, WILLIAM. Extended abdominal radical operation for cancer of the uterus. Surg., Gynec. & Obst. 1913, xvi, 3, 251.

Idem. Die klinische Stellung des Carcinoma corporis uteri. Arch. f. Gynaek., 1913, c, 153.

WEINBRENNER, C. Die Behandlung der Genital-carcinoma mit Mesothorium. Monatschr. f. Geburtsh. u. Gynaek.,1914, xxxix, 181.

WERTHEIM. Radium Behandlung des Gebaermutterkrebses. Wien. klin. Wchnschr., 1913, xxvi, 1648.

Idem. Internat. Cong. Med., Lond., 1913.

WICKHAM, L., and DEGRAIS, P. Radium thérapie, cancer de l'utérus. Paris: 1912, 2nd ed.

WILSON. The results of abdominal operative treatment of cancer of the uterus. Med. Press & Circular, 1914, xcviii, 302.

SECONDARY MELANO-EPITHELIOMA OF THE BLADDER

By C. G. RICHARDS, M.D., Rochester, Minnesota
From the Department of Urology, Mayo Clinic

MELANO-EPITHELIOMA is always primary in the eye or in pigmented moles of the skin, and it metastasizes so rapidly that the patient succumbs soon after the appearance of the growth. The extreme rarity of its occurence in the bladder seems to warrant the report of the clinical history and subsequent course of the disease in a case under our observation. Mention has been found in the literature of but one similar case.[1] The history of our patient is as follows:

Case 218587, a man aged 45. The patient's mother died of cancer of the stomach at the age of 73, and, like the patient, she had had pigmented moles irregularly distributed over the entire body. For the past five or six years the patient had noticed that a rather large mole situated on the right side of the abdomen near the umbilicus had a core of granular débris which could be expressed, and two months previously it had begun to enlarge and had a tendency to bleed. Because of the bleeding the patient consulted his physician who excised the growth. Histologic examination revealed melano-epithelioma. Further surgical advice was sought, and the examination was negative except for slight enlargement of the inguinal lymph-nodes. The urinary findings were negative. A gland removed from the groin was found to be malignant in character, and therefore all the lymphatic glands in both groins and Scarpa's triangle were removed; the external saphenous vein was ligated. While the patient was convalescing from the operation radium treatment was begun, and was continued at frequent intervals. Eight months later another small gland in the inguinal region was discovered, which proved to be of the nature of those previously removed. Ten months later increased frequency of urination and diminution in the size of the stream, and nocturia were noticed. The urine contained a number of erythrocytes and pus-cells.

On cystoscopic examination multiple areas of black rounded tumors varying in size from 2 to 5 centimeters were found on the right base of the bladder anterior to the right meatus. On the left wall two of the tumors had pedicles; the others were sessile.

As soon as the bladder condition was discovered intravesical radium treatment was instituted. To the present time 400 milligram hours have been given. At the last cystoscopic examination one month ago no material change was noticeable except perhaps a slight increase in the size of one or two of the tumors.

[1] Targett, J. H. Secondary melanotic sarcoma of the bladder. Tr. Path. Soc., Lond., 1890-1891, xlii, 214-215.

SACRAL SUSPENSION OF THE UTERUS FOR THE RELIEF OF PATHOLOGICAL MECHANICAL RETROVERSION AND DESCENSUS[1]

By JOHN VAN DOREN YOUNG, M.D., F.A.C.S., New York

THE general subject of retroversion of the uterus has been voluminously treated in medical literature, and views of great diversity have been expressed as to its etiology, importance, and pathology. Much confusion exists in the medical mind as to the normal, as well as the pathological position of the uterus, if one may judge from the writings and discussions of those who are accepted authorities in gynecology. Some writers go so far as to state that a pathological position of the uterus is "normal in some women." There can be no question that some suffer less from a given pathology than others, but that does not make it "normal" even in those cases. There is a normal position of the uterus, and there are variations that are within physiological limits, but there is a point beyond which lies the area of pathology.

In defining and passing on the importance of abnormality of position of the uterus, several factors must be considered: (1) age of patient, (2) position of the body at the time of examination, (3) skeletal poise, (4) muscular development, (5) birth trauma, and (6) occupation.

1. *Age of patient.* For the gynecologist, woman's life is divided into three stages: first, before childbearing, second, during childbearing, and, third, after childbearing. It is manifest that these three stages will have distinct gynecological conditions: that fact must be recognized before the examiner can determine the actual or relative normality of a given case.

A patient in the first stage suffering from retroversion, causing relative sterility, future years of menstrual disturbances, and raising troublesome marital questions would demand relief, when the same degree of deformity could well be disregarded after the menopause.

Furthermore, the changes of the period of childbearing and the postmenopause atrophy present conditions that must be analyzed.

2. *Position of the body at the time of examination.* I desire to call particular attention to the fact that an examination in both the dorsal and the standing positions is absolutely necessary in judging of the importance of a retroversion, of the degree of descensus and of the result of an operation.

3. *Skeletal poise.* The study of skeletal poise is essential to the understanding and to the treatment of all ptosed conditions of the viscera. Uterine ptosis is no exception to this rule.

The ill-effect of faulty poise is far-reaching, and its correction is absolutely essential. But while faulty poise can put too great a strain on the ligamental supports of the uterus, thereby lengthening them, its correction cannot shorten them if they are stretched beyond their elastic limit.

4. *Muscular development.* Muscular tone as a part of a generally well-developed body is a direct advantage to a patient, but in a pathological mechanical retroversion or descensus of the uterus I have seldom seen any improvement in uterine position from improvement in general health or muscular tone. It is my opinion that as many retroverted ptosed uteri are found in well-developed women as in poorly-developed women.

5. *Birth trauma.* Birth trauma is of the greatest importance as a contributing cause in retroversion and descensus.

Subinvolution means increased weight and bulk to the uterus, lax ligaments, and, therefore, less resistance to positive intra-abdominal pressure, and greater surface to receive this pressure.

At this point allow me to call your attention to the fact that the uterine ligaments are amply strong enough to hold a normal uterus in normal position with a normal body poise and an intact pelvic diaphragm, but the resistant margin beyond this is not great.

Cervical birth trauma with resultant in-

[1] Read before the Brooklyn Obstetrical Society, February 8, 1919

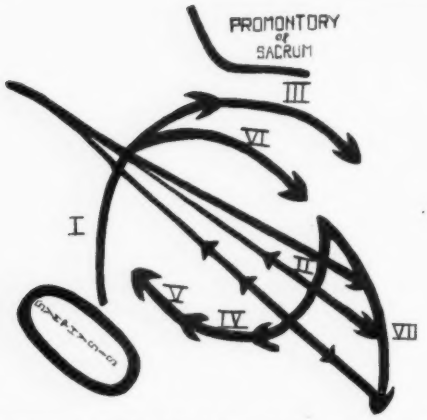


Diagram 1. *I*, Physiological excursion of the fundus; *II*, physiological excursion of the cervix; *III*, pathological excursion of the fundus; *IV*, pathological excursion of the cervix; *V*, experimental excursion of the cervix; *VI*, descensus excursion of the fundus; *VII*, descensus excursion of the cervix.

fection and enlargement of the cervical arm of the uterine lever, distorts uterine balance and predisposes to general uterine enlargement and consequent overweight.

Injury to the rectovaginal and vesicovaginal endopelvic fascia, with rectocele and cystocele pocketing of the rectal and vesical contents, straining to empty the organs, and lack of fascial support, are the most easily recognized causes of retroversion and descensus. The laceration of the superficial perineal muscles with the tearing away of the sphinter ani from the conjoined tendon increases the predisposition to rectocele.

Separation of the levators with lateral retraction of these muscles, and, thereby, a loss of pelvic diaphragmatic support, is a most important link in the chain of birth injury.

6. *Occupation.* All standing occupations predispose to faulty poise and, therefore, show an increased proportion of retroversion and descensus.

The contributing causes are: constipation; tight or faulty corsets; lack of attention to the emptying of the bladder, especially during the menstrual period; abortions; falls, especially in the sitting posture; lifting and carrying of heavy weights; horseback riding.

My conception of what might be called the absolutely normal position of the uterus is shown in Figure 1, a young woman with empty bladder and bowel, the patient in the standing posture. Variations from this picture are well within physiological limits, and variations of even a greater degree are compatible with health. Note the position and axis of the vagina, and of the uterus, and the acute angle produced by the meeting of these axes. Note also the uterosacral ligament, observing its course and general character; the round ligament, its position as a guy rope to the fundus, and the direction and uselessness of these ligaments for support in the standing position.

For convenience of description I divide retroversions into two classes: physiological and pathological. These two conditions blend, and by easy stages merge into the condition of descensus, which is the predecessor of prolapse. See Diagram 1, which depicts the lines of excursion of the fundus and cervix in all four of these conditions.

Physiological retroversion is the condition in which the fundal excursion does not go below the promontory of the sacrum, and where the cervical excursion is in proportion.

Pathological mechanical retroversion may be described as a retroversion of the fundus, a moving forward of the lower segment, and a descensus of the whole organ (see Figure 2). Note that in this position the fundus is below the promontory of the sacrum and presses on the rectum between the uterosacral ligaments with resultant fæcal stasis.

The cervix impinges on the trigone and is lifted out of the seminal pool, with consequent relative sterility; the vagina is shortened and the upper portion displaced forward in the pelvis, and it becomes perpendicular when the patient is standing.

The adnexa are prolapsed in the pouch of Douglas. The bladder fundus is pulled back by the uterus and is left free to rise into the abdomen, and is exposed to intra-abdominal pressure in a disadvantageous position. The fundus is posterior, the cervix is anterior; the anterior or inferior surface becomes the superior; the posterior or superior surface becomes the inferior.

The venous return is impeded by the twisting of the broad ligaments, with con-

Fig. 1. Normal position of the uterus in a young woman with empty bladder, the patient standing.

Fig. 2. Pathological mechanical retroversion.

sequent varicosities of the pampiniform plexus. The infundibulopelvic ligaments are dragged over the edge of the true pelvis, obstructing the venous return, and there is a consequent circulatory stasis of both uterus and adnexa.

The axes of the uterus and of the vagina often form an obtuse angle, or the uterine axis is pushed back until they form a straight line or a reverse angle even greater than a straight line.

Figure 3 shows the relation of the normally placed organs viewed from above. Figure 4 shows pathological mechanical retroversion viewed from above.

The next malposition of the uterus which we are to consider is descensus. This deformity may be preceded by a retroversion, or the early stages may precede or may be synchronous with the accompanying retroversion. In any event, the two misplacements are associated, and the downward course of the uterus is due to a marked yielding of the uterosacral swing which places the uterus in the axis of the birth canal, where intra-abdominal pressure is the greatest and the ligaments are least able to resist it. It must also be noticed here that the curve of the descensus is changed, both in the fundal and in the cervical arc, from that of retroversion as the fundus nears the sacrum, and the downward course is explained by the loss of the support of the uterosacral ligaments.

I have found one other group of cases, namely, those in which the uterus seemed in normal position in the dorsal examination, but in which, on looking further for the cause of the backache, I found that with the least amount of effort, the cervix could be placed in the extreme experimental position (see Diagram 1), and that in the standing position there was well-marked descensus, showing a marked loss of the uterosacral support. I believe this is an important condition, which should be recognized, as these patients suffer greatly.

One other condition which I wish to mention is that of intermittent retroversion of the physiological and pathological classes. This condition is present where the balance of ligamental resistance and intra-abdominal pressure is wavering, and where, part of the time, the ligaments are not equal to their task.

Following in natural sequence upon descensus is prolapse, which is a change of degree only and not of kind.

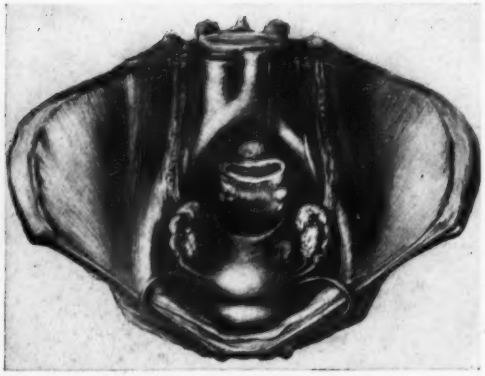


Fig. 3. Relation of the normally placed organs viewed from above.

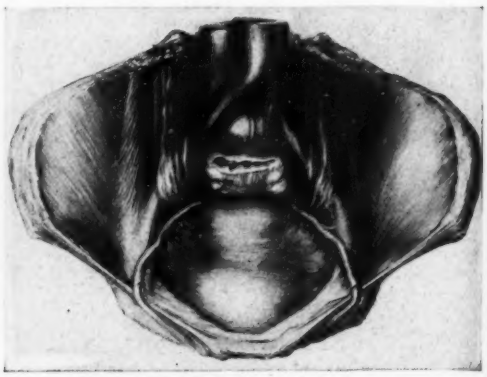


Fig. 4. Pathological mechanical retroversion viewed from above.

The influence of pregnancy must be taken into consideration in the study of these cases, and may be briefly outlined as follows: a retroversion or descensus which antedates a pregnancy is not benefited thereby, but often made worse. A postpartum retroversion, on the other hand, may often be permanently relieved if treated and the uterus replaced during the later involution period and a properly-fitting pessary introduced and worn long enough to insure a return to normality.

In regard to the frequency of occurrence, my tabulation of the 6,134 cases examined shows retroposition in 2,238 cases, or 37 per cent, which is in accordance with the usual experience (see Table I). A relative sterility is found: less than 2 children per family.

Symptoms are due to pressure and pelvic stasis. They are: backache; bearing-down pains; dyspareunia; mental irritability, to melancholia; relative sterility; constipation.

Treatment is divided into general, local, pessary, and operative.

The first two must, and often the third may, precede operation, as preparatory thereto.

Pessaries are also of use in cases where, for any reason, operation is contra-indicated, and also in postpartum cases.

OPERATION

I desire to emphasize the fact that an operation to bear the test of time must take into consideration the anatomy, physics, mechanics, and dynamics of the pelvis, and to ask you to remember that there are very marked changes in the pelvic structures during and after childbearing.

The vital point is this: we are engaged in reconstructive surgery, which must be based on correct theories.

Contemplating operation, one must recall that the uterus is a ligamentally-hung organ in the bony pelvis, below which is the muscular and fascial pelvic diaphragm, the function of which is the reception of intra-abdominal pressure and the support of the rectum and the bladder.

Now bear in mind that this pelvic diaphragm is injured by childbirth, as follows: first, superficially, by laceration of the sphincter vaginæ, of the transversus perinei, by injury to the conjoined tendon and retraction of the sphincter ani; second, by laceration with separation and lateral retraction of the levator; laceration of the vesicovaginal endopelvic fascia with cystocele; laceration of the rectovaginal endopelvic fascia with rectocele; any variation or combination of the above, or a complete laceration that opens into the rectum.

Note also that retroversion and descensus occur in those who have never been pregnant.

If, therefore, retroversion and descensus occur independently of birth trauma, then it would seem logical that the repair of the trauma could only be expected to relieve uterine deformity developed subsequently,

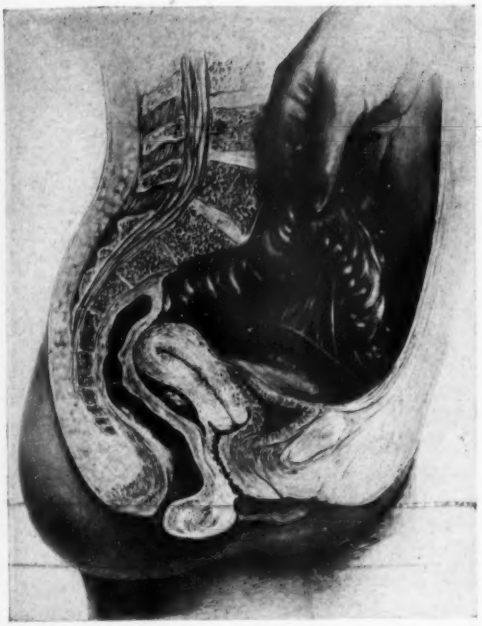


Fig. 5. Perisigmoidal adhesions, necessitating freeing of the sigmoid.

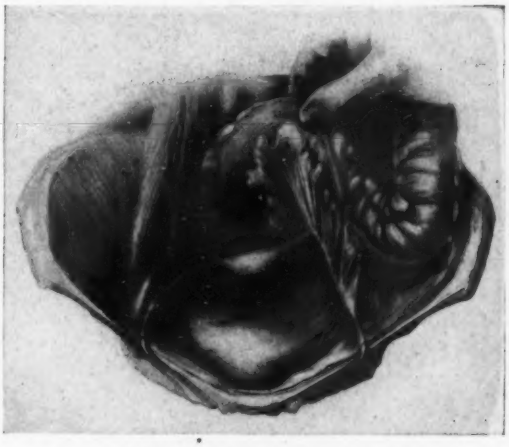


Fig. 6. Perisigmoidal adhesions.

and not prior, to the injury, and in those cases only where the ligaments have not been stretched beyond their elastic limit.

Experience alone will enable one to judge whether in a given case relief may be expected from repair. This experience must be applied with great care to borderline cases and intermittent retroversion, as I am convinced that herein lies the cause of much confusion of views.

From the above the conclusion may be drawn that the benefit accruing from pelvic diaphragmatic repair is relative to that structure only, and that the uterus must rely on its ligaments alone for support.

The uterine ligaments chiefly concerned in retroversion and descensus are the uterosacral and the round.

The importance of the uterosacral ligaments in operations for the relief of these conditions was stressed in my first paper on this subject, read before the New York Obstetrical Society in May, 1903, and printed in the *Medical Record* of October 24, 1903, again in my second paper on this subject, read before the Section on Obstetrics and Gynecology of the New York Academy of Medicine, 1906, again in a third paper, read before the First District Branch of the New York State Society and printed in the *American Journal of Surgery*, in March, 1909, and again in my fourth paper, read before the Medical Society of the County of New York, October 25, 1915. In each succeeding paper I have expressed an ever firmer conviction that this theory is fundamentally correct. Now, after twenty years of work, I am of the same opinion.

The uterosacrals arise laterally from the corporocervical junction of the posterior wall of the uterus. Their direction is upward and slightly backward, and the ligaments are inserted into the anterior surface of the first and upper edge of the second sacral vertebræ. The fibrous tissue which enters into their formation is the thickened very strong edge of the pelvic fascia as it separates to allow the rectum to pass through.

For our purpose they may be divided into three parts: the uterine third, the middle third, and the sacral third. The uterine third is rounded and contains more muscular and elastic tissue. The middle, or weakest portion, mostly fibrous, is the part where the yielding of the ligament occurs. The sacral third is fan-shaped, very strong, and is composed solely of fibrous tissue. These liga-

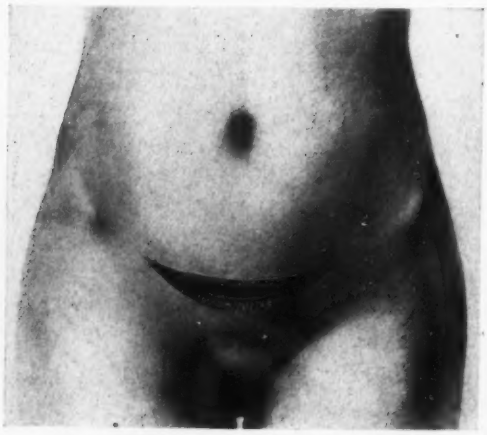


Fig. 7. Curved Pfannenstiel incision.

ments are covered by peritoneum. The function of these ligaments is suspensory alone, and they are the only ligaments that run (when the patient is in the standing position) from the uterus to the bone above.

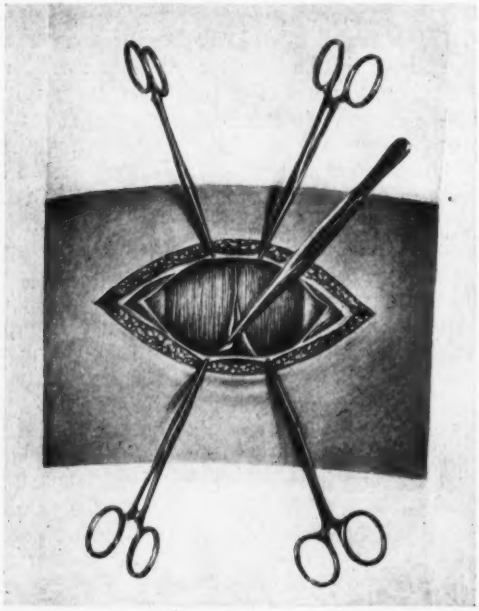


Fig. 8. Curved Pfannenstiel incision.

The round ligaments are the guy ropes to hold the fundus forward and downward, when the patient stands.

To summarize, my conception of the indicated surgery is as follows:

In nullipara, for physiological retroversion, round ligament shortening; for pathological mechanical retroversion and descensus, sacral suspension and, if needed, round ligament shortening; when there is a conical long cervix, the tracheloplastic operation of Sturmdorf.

In multipara, the restoration of all birth trauma; dilatation and curettage if indicated; for the hypertrophied infected lacerated cervix, the tracheloplastic operation for cystocele, the restoration of the vesicovaginal endopelvic fascia by the method of Rawls; for rectocele, the restoration of the rectovaginal endopelvic fascia, and the muscular interposition perineorrhaphy.

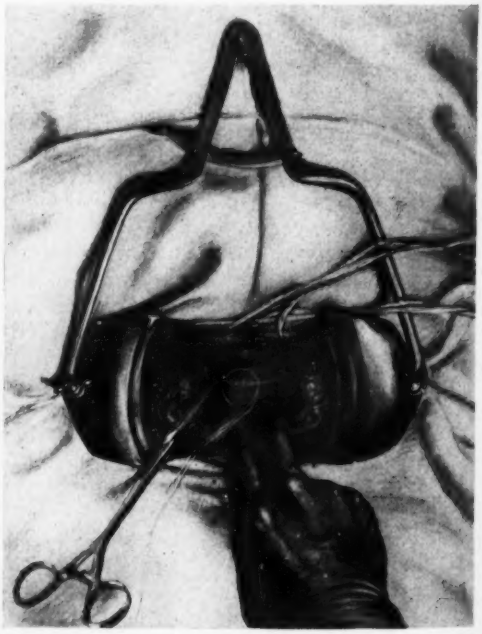


Fig. 9. A long catgut stitch is passed through the base of the left uterosacral ligament. A similar stitch is then passed through the base of the right uterosacral ligament.

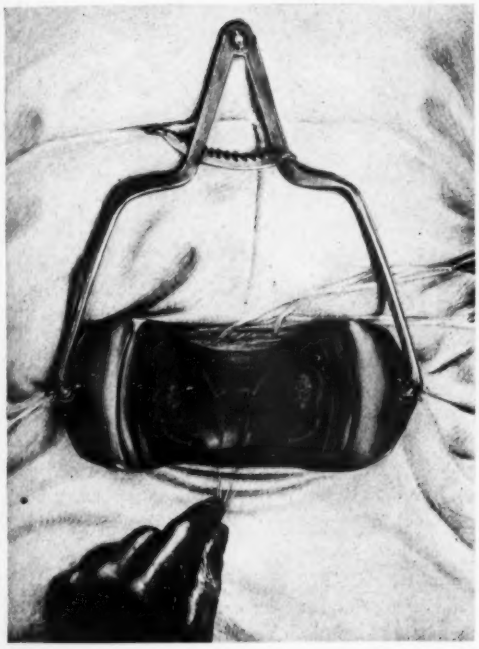


Fig. 10. The stitches passed through the bases of the uterosacral ligament serve two purposes: they hold the uterus out of the way without injury to it, and they bring the ligaments into view.

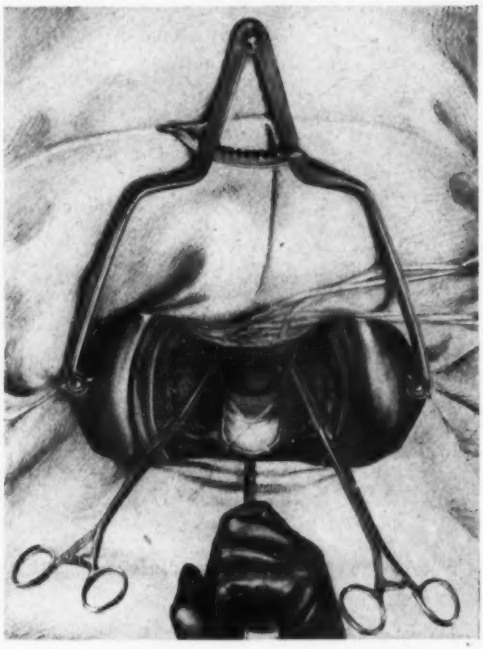


Fig. 11. A trowel used for demonstration purposes.

SACRAL SUSPENSION

The incision of choice is the curved Pfannenstie[1], shown in Figures 7 and 8. After the abdomen is opened, the patient is placed in the extreme Trendelenburg position and the intestines are gravitated into the abdominal cavity, and held in place by oil-impregnated pads. All gauze wipes that enter the abdomen are also oil-impregnated.

Inspection then determines the indicated surgery, and this surgery is performed prior to the suspension. At this point the uterus is lifted up and the sigmoid inspected. In these cases I have so frequently found perisigmoidal adhesions, that I have come to consider the freeing of the sigmoid a part of the operation (see Figures 5 and 6). As shown in these pictures, the sigmoid is frequently found adherent to the round ligament as far as the internal ring. Twice I have found it adherent to the bladder.

The uterus being held upward, the base of the left uterosacral ligament, or the one opposite to the operator, is picked up by a long French clamp (clamp 1) and a long catgut stitch is passed through it (see Figure 9). It is then tied. This is repeated on the right ligament (clamp 2). These stitches are then brought out over the edge of the wound and held by an assistant, clamps 1 and 2 having been removed as each stitch is placed. These stitches serve two purposes: they hold the uterus out of the way, without injury to it, and, secondly, they bring the ligaments well into view (Figure 10). For demonstration purposes, a trowel may be used, as seen in Figure 11.

The left ligament, or the one opposite to the operator, is now brought into view and the point of shortening marked by a French clamp (clamp 3; see Figure 11). The other ligament is then exposed and a point on it opposite to clamp 3 is grasped by another French clamp (clamp 4). The operator determines the point of shortening by traction on the ligaments, first, on one at a time, then on both

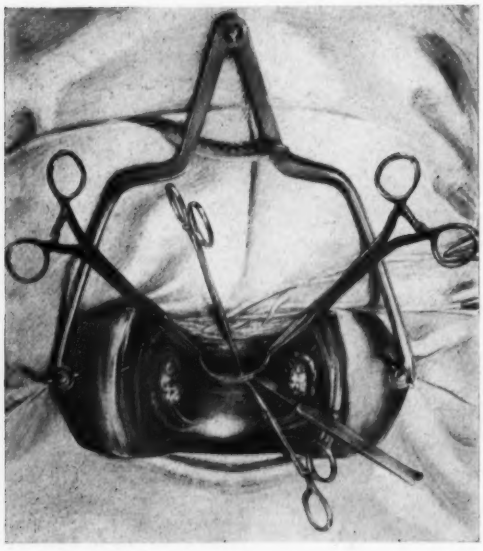


Fig. 12. Two Allis clamps grasp the ligament at its origin.

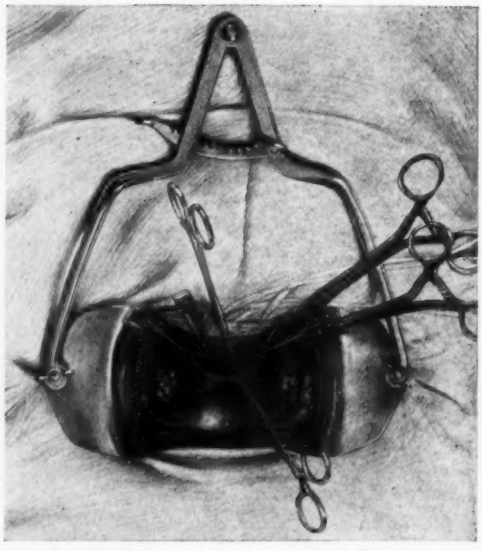


Fig. 12,A. A French clamp is placed on the ligament midway between clamp 3 and the Allis clamps, marking the reduplication point, left ligament.

together, being careful to allow ample rectal room, and at the same time to replace the cervix in its normal position. This may be checked off by putting two fingers in the space between clamps 3 and 4 and the anterior surface of the sacrum with the palmar surface of the fingers toward the uterus. In this way the operator may judge exactly the length of the proposed reconstructed sacral swing.

Two Allis clamps now grasp the ligament at its origin (see Figure 12 for their position). The breadth of the jaw of the clamp is parallel with the ligament, one clamp above and the other below it, just at the site of the first catgut suture. Traction on these two clamps will draw the lower segment of the uterus into view and pull upon the base of the ligament. This will enable the operator to take the next step, which is to make the button hole. This is made at the base of the ligament by means of a knife and extends along its median line. It should cut the catgut traction stitch. This incision should be 1 centimeter long and down to the uterine tissue. It is then extended to 1.5 centimeters along the ligament by placing a blunt pair of scissors in the cut and opening the blades.

A French clamp (clamp 5) is then placed on the ligament midway between clamp 3 and the Allis clamps, marking the reduplication point (Figure 12, A, left ligament). Clamp 3 and the Allis clamps are now approximated to see if the sacral end of the reduplicated ligament will reach the button hole without strain.

A medium-sized Pagenstecher linen suture is now put in place in the ligament at the site of clamp 3, which is then removed (shown on the right ligament, Figure 13).

The needle is then introduced into the button hole and is made to penetrate the uterine tissue to a sufficient depth to give a firm hold (see Figure 12, left ligament), after which the suture is tied. During this procedure clamp 5 is drawn upward and backward and slightly outward, as shown in Figure 12, A, right ligament. This brings into view the three arms of the ligament, uterine, middle and sacral. A second stitch is then placed through the lips of the button hole at right angles to the incision, and as it is introduced, first one, and then the other Allis clamp is removed. Before tying this second

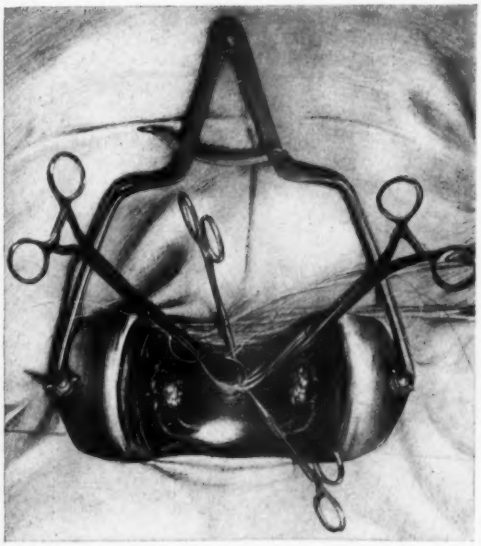


Fig. 13. A medium-sized Pagenstecher linen suture is inserted in the ligament at the site of clamp which is now removed.

Fig. 14. Completed operation.

stitch, the first one is cut short. This second stitch closes the button hole, buries the first stitch, and completes the implantation of the sacral arm of the reduplicated ligament. This second stitch is left long for traction and marking purposes.

A third stitch is then placed through the three layers or arms of the reduplicated ligament, midway in the folded-over area, or, if the reduplication is long enough to need it, two stitches may be used. Care must be taken to penetrate all three arms of the reduplication in each stitch to a sufficient depth to hold strongly. A stitch is then introduced at the site of clamp 5 and carried through the sacral arm of the reduplicated ligament in such a manner as will make the joining smooth. All these stitches are left long and attached to clamps outside the abdomen for marking purposes.

The procedure is then repeated on the opposite ligament.

By slight traction on these linen stitches the operator may judge of the completeness of his work and the length of the newly-made ligaments. As a further test, two fingers may be placed, as at the time of placing clamps 3 and 4.

The linen stitches are then cut short. The knots may be covered by a Lembert stitch, involving only the peritoneum. The completed operation is shown in the illustration, Figure 14.

If, in the opinion of the operator, the fundus needs holding downward and forward, the round ligaments are shortened, either by the Alexander operation, or by a modification of the Gilliam operation which leaves no pockets in the peritoneum.

TOTAL NUMBER OF CASES EXAMINED					8134	
TOTAL NUMBER OF RETROPOSITIONS					2238	
AGE						
10–20	20–30	30–40	40–50	50–+	306	366
118	1028	717	275	104		
CIVIL STATE			MISC.		INJURIES	
			1446	85		
1912	3557	326		20 12 3 50	967	961
1445	777	576	16	1	489	887

Table I. Showing frequency occurrence.

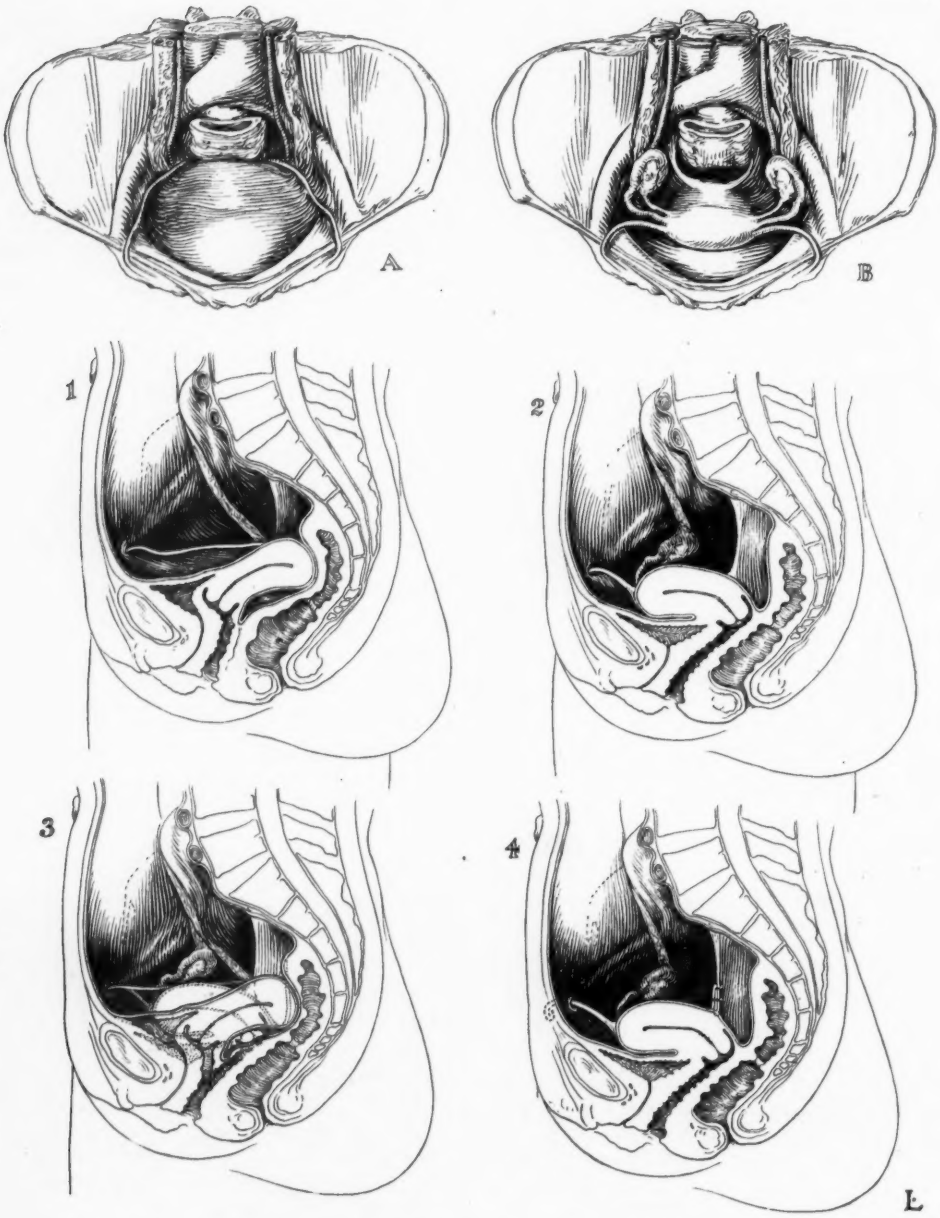


Fig. 15. Diagrammatic recapitulation of the condition and of the procedure.

I have performed 270 sacral suspensions of the uterus and 10 of the cervical stump after hysterectomy, a total of 280, with a mortality of 2, one from acute nephritis, the other where excessive peritoneal trauma of a previous operation produced insurmountable complications.

Where it is necessary to reconstruct extensive birth trauma, the operation should be done in two stages, separated by one week or more.

The labors I have attended after sacral suspension have been most satisfactory. The greatest number of labors in any one case has been four (Mrs. E., operated on, November 18, 1912, at the New York Polyclinic Hospital). The patient has remained well since without gynecological symptoms. The uterus is now in normal position; adnexa negative.

My oldest patient, operated on at the New York Polyclinic Hospital, was 62 years of age.

She had complete prolapse, a very large right inguinal hernia, which was in turn covered by a large ventral hernia. The first operation was tracheloplastic on the cervix, muscular interposition perineorrhaphy: second operation, sacral suspension Alexander, right inguinal herniotomy; Blake operation on the ventral hernia.

She was well for two years when she returned with an acute traumatic laceration of the perineum, cause unknown. The cystocele which persisted was then operated on (September 4, 1918, New York Polyclinic Hospital) by the Rawls method, and the perineum restored: recovery uneventful and complete.

As illustrating the value of this procedure in cases in which other forms of operation have failed (of which I have had many), I report Case No. 258.

Mrs. G. aged 20, nullipara, suffered from most severe dysmenorrhœa and menorrhagia all her menstrual life. Appendectomy, 1910. She had been twice dilated under ether and a stem pessary put in place and left in six months each time. In October, 1915, she had a ventral suspension with a suspension of the left ovary.

I first saw her May, 1916, at the age of 18 and suggested a sacral suspension. For the two years following she was under the best medical advice and the care of specialists, with no relief. I saw her again May 25, 1918, and advised operation.

Examination showed the uterus firmly adherent to the anterior abdominal wall midway between the symphysis and the umbilicus. As she was growing worse and the pain was relieved only by morphine, I urged operation, which I did on June 24, 1918. The uterus was 4½ inches long, internal measurement. There was a fibrostenotic infected cervix. I performed a tracheloplastic operation; a resection of the abdominal scar. A very strong broad band of adhesions, which had firmly fixed the uterus, was resected from the fundus. A cyst was removed from the right ovary, sacral suspension performed and round ligaments shortened. Recovery uneventful.

Examination September 12, 1918, showed the uterus in normal position; adnexa negative. The periods since operation have been profuse; only one slightly painful. The patient has regained her health.

On October 17, 1916, I operated for the late Dr. White, of Hackensack, N. J., on a patient three and a half months pregnant, for an adherent pathological retroversion. The pregnancy added many difficulties to the operation, but the patient made a good recovery and carried the child until the seventh month. The operation was hazarded because she had never carried beyond the fourth month, and this was her fifth pregnancy.

It is of the most vital importance in all reconstructive surgery of this type that a true conception of the injury and of the resultant deformity be evolved, and that the operation rebuild the traumatized structures and thereby replace the retroverted or ptosed organs.

My claim for the procedures mapped out is that the trauma is recognized and correctly repaired, and that the result is restoration to normal position and function. That the technique described has proved satisfactory in my hands confirms the basic correctness of the procedure.

That there is much to be done in these operative procedures is not the fault of the operation, but is inherent in the condition. To do less than all the needed repair is neglect.

MEGA-DUODENUM

Report of a Case in an Infant[1]

By F. G. DUBOSE, M.D., F.A.C.S., Selma, Alabama

A SEARCH of literature finds no recorded case of giant duodenum in an infant. The symptoms in the case reported began when the child was 3 days old, persisting until the eighth week of its life when it was first seen by me. The condition was diagnosed from the physical and X-ray examinations. Downes, of New York, reports a case in a child four and one-half years old.[2]

The clinical course in the infant is similar to pyloric stenosis in its subjective expression, and in its effect in producing rapid emaciation. The differential diagnosis is made by the appearance of bile in the vomitus and in the absence of a palpable pyloric tumor. In the case here reported there was a rapid loss of weight, vomiting occurring at irregular intervals without definite relation to food or fluid intake, and after nursing the regurgitated milk returning bile stained, and the subsequent vomitus containing bile and duodenal fluid, in larger amounts than fluids ingested. Through the thin and emaciated abdominal walls of the infant, as in pyloric stenosis, the visible coils of intestines and peristaltic waves were easily observed. Immediately after nursing and before the onset of vomiting the distended stomach and duodenum could be seen in the epigastrium. The roentgenograms demonstrated the abnormal condition with unusual accuracy and clearness of definition.

Normal delivery, fourth child, of healthy parentage. Weight at birth 7.5 pounds. She began vomiting yellow fluid the third day. At this time the child was being nursed at two hour intervals. The interval of nursing was lengthened to four hours without effect. Nursing with the head down and body elevated was tried, but the vomiting continued. Various medicines were prescribed by the attending physician without benefit.

When first examined by me November 23, 1918, the child weighed 5.5 pounds, showing a loss of 2

[2]W. A. Downes. Ann. Surg., 1917, lxvi, 436.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 1. Roentgenogram showing stomach filled, narrow pylorus, enormous ovoid duodenum and some barium in the intestines.

Fig. 2. Stomach smaller, duodenum larger, pylorus distinct.

Fig. 3. The stomach is almost empty. A small portion of barium meal remains at the cardiac extremity.

[1]Read before the Dallas County Medical Society, Selma, Alabama.

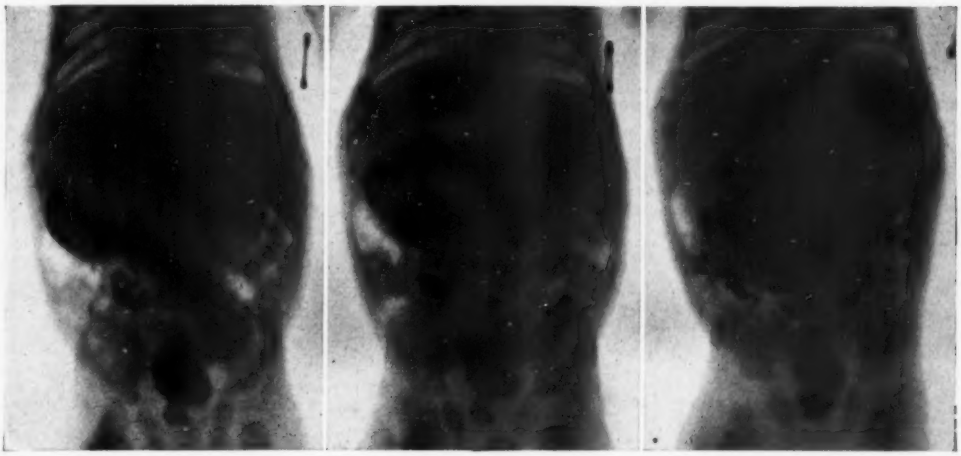


Fig. 4. Fig. 5. Fig. 6.

Fig. 4. The stomach is completely empty, the duodenum filled.

Fig. 5. Stomach beginning to refill after retching.
Fig. 6. Stomach refilled, duodenum empty.

pounds in two months. She was apathetic, took no notice of people or things, never cried. Her eyes had the Mongolian slant. The tongue was larger than normal and slightly protruding. All of these findings and the facial expression were suggestive of cretinism. Vomiting occurred at irregular intervals, either bile stained milk or duodenal fluid. She was fed a barium meal with a teaspoon, beginning at 11:20 a.m., under such difficulties that it required 45 minutes to feed 2 ounces.

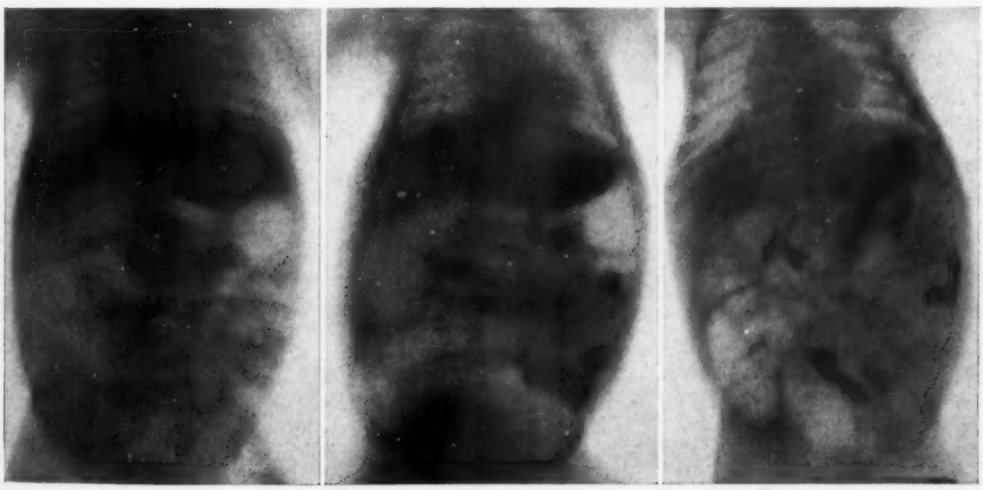


Fig. 7. Fig. 8. Fig. 9.

Fig. 7. Stomach filled with barium meal. Roentgenogram taken one month later, immediately after feeding two ounces.

Fig. 8. Roentgenogram taken 15 minutes later, showing gastro-enterostomy opening with barium meal in jejunum. The pylorus is closed.

Fig. 9. Roentgenogram taken 15 minutes later, showing the stomach rapidly emptying through the gastro-enterostomy opening, complete closure of pylorus. There is a small amount of barium meal in the loop proximal to the duodenojejunal junction.

At 12:05 p.m., November 23, 1918, the first X-ray plate was taken, showing a filled stomach, a narrow pylorus, an enormous ovoid duodenum, and some barium in the intestines. Ten minutes later, (Figure 2) shows the stomach smaller and the duodenum larger with a distinct pylorus. At 12:30 the stomach was almost empty, only a small portion of the barium meal remaining at the cardiac extremity (Figure 3). Fifteen minutes later the stomach was completely empty and the duodenum filled (Figure 4). Some retching occurred but no vomiting in the next fifteen minute interval, and (Figure 5), taken at 1:00 p.m., showed the stomach beginning to refill by regurgitation from the duodenum. Three hours and fifteen minutes were required, as shown in Figure 6, for the duodenum completely to empty itself into the stomach, which is here shown refilled and distended with the barium meal.

The globular appearance of the duodenum in the X-ray plates would justify the opinion that there was possibly a diverticulum of the duodenum. The partial occlusion of the duodenum as it appears in the roentgenograms seems to be not the duodenojejunal junction, but cephelad to it in the fourth portion of the duodenum. Operation was advised as the only possible and as a very barely possible means of saving the infant's life. The roentgenograms demonstrated the fact that the obstruction was partial, that it was caudad to the bile and pancreatic ducts. The duration of eight weeks with a loss of 2 pounds in body weight was additional confirmation of partial obstruction. These facts made the operator prefer doing a gastro-enterostomy with occlusion of the pylorus as a surgical procedure in this case rather than a duodenojejunostomy, which is without question the operation of choice in complete arteriomesenteric obstruction at the duodenojejunal junction.[1] On November 28, 1918, under ether anæsthesia, through a median upper abdominal incision, a posterior gastro-enterostomy was done. The pylorus was tied off with a pursestring suture of linen and the gastroduodenal serosa approximated over this with interrupted Lembert sutures. The time consumed in operation was 35 minutes. It was observed on opening the abdomen that the duodenum was of enormous size, dilated and flaccid. There was neither diverticulum, constriction, adhesive band, or kink of the duodenum, but the jejunum was collapsed beyond its origin at the mesentery, having an appearance such as is found in mechanical obstruction of the intestines caudad to the point of obstruction. It is probable that in this case we have a true arteriomesenteric obstruction at the duodenojejunal flexure of congenital origin, some anatomical defect, producing either pressure from the superior mesenteric artery overlying it, or from some abnormality in the structure of the mesentery, with a resulting kink at the duodenojejunal junction, and that the mega-duodenum was a sequence of this rather than a congenital giant duodenum. The postoperative convalescence

[1] W. H. Fisher. Ann. Surg., 1918, lxviii, 582.

Fig. 10. Roentgenogram taken 3 hours later. The stomach is practically empty. The barium meal is in the large intestines.

was uninterrupted, with immediate cessation of periodic and persistent vomiting.

Administration of small doses of thyroid extract was begun in December. On December 21, 1918, a second series of roentgenograms was made. Figure 7, taken at 11:00 a.m. immediately after a barium meal, showed the stomach filled. Figure 8, taken at 11:15 a.m., showed the stomach rapidly emptying through gastro-enterostomy opening. There was duodenal shadow, showing that the pylorus was completely occluded. A small portion of barium meal was already entering distant loops of the small intestine. Figure 9, taken at 11:30, showed a slight amount of barium meal in the afferent portion of long loop of jejunum, together with particles of barium meal in small intestines. Figure 10, taken at 3:00 p.m., showed the stomach empty, the small intestines empty, and the barium meal in the large intestine.

In none of the second series, of which the four illustrations were selected for the purpose of demonstration, is the barium meal to be seen in any part of the duodenum, showing that several months after operation the occlusion of the pylorus was persistent, and no doubt will be permanent.

On March 10, 1919, three and half months after operation the child weighed 11¾ pounds, a gain of 6¼ pounds.

The rarity of this condition leaves room for considerable speculation with reference to its etiology, and to the best surgical operation for its relief: whether the operation of choice in the acute dilatation of the duodenum that

of duodenojejunostomy is equally applicable here, or whether the operation of the long loop posterior gastro-enterostomy, as done by me, with the occlusion of the pylorus, or the no loop gastro-enterostomy as done by Downes in the only other case reported, is a question largely to be determined by the pathology observed during the course of operation. It does appear in this case that there was some abnormality at the duodenojejunal junction. When done in infancy and early childhood, it appears that the posterior gastro-enterostomy with occlusion of the pylorus is sufficient, and that the end-result of such operation as obtained in the two cases reported would warrant its performance.

The possibility of this being a congenital abnormality, or defect, would be supported in a measure by the suspicion of cretinism in this infant. At the same time it is entirely possible that such a giant duodenum could develop within 8 weeks after birth, as a result of partial obstruction at the duodenojejunal junction of congenital origin.

Gastro-enterostomy with pyloric occlusion is the operation of choice in partial obstruction at the duodenojejunal flexure in infants, for the following reasons:

CONCLUSIONS

1. The dilated stomach is drained into jejunum.
2. Pyloric occlusion diverts bile and pancreatic fluid into jejunum and prevents regurgitation into stomach.
3. Bile, pancreatic, and duodenal fluids with the contained hormones, so greatly needed, are more largely conserved than if pylorus were not occluded.
4. Regurgitation into stomach and loss of fluids is lessened through cessation of vomiting—more certainly obtained in gastro-enterostomy with pyloric occlusion than in duodenojejunostomy.
5. Pyloric occlusion is essential.
6. Five months have elapsed since this operation was done, and the infant weighs 12 pounds, 8 ounces, April 19, 1919.

AN EXPERIMENTAL STUDY OF THE USE OF DETACHED OMENTAL GRAFTS IN INTESTINAL SURGERY

By WALTER L. FINTON, M.D., F.A.C.S., Jackson, Michigan
AND
MAX MINOR PEET, A.M. M.D., Ann Arbor, Michigan
Assistant Professor of Surgery, University of Michigan

At the present time when every effort is being made to facilitate operations within the abdomen, it seems especially important that a clear understanding of the possibilities of the omental graft should be obtained.

The functions of the great omentum are still the subject of considerable speculation. Rubin, from a pathological and experimental study, came to the following conclusions: "The omentum has no spontaneous motility; no demonstrable chemotaxis; no 'intelligent' or spontaneous protective rôle; no ability to restore vitality or vascular supply to other organs; it does not always close defects; its usefulness depends on its power to form adhesions, to absorb toxic products, and to destroy foreign substances through its phagocytic agents; it acts as any mesentery giving fixation to certain viscera, and carrying their blood supply; its protective properties are due to the peritoneal layers; detached omentum becomes necrotic and is useless."

The use of omental grafts, both attached and detached, has been advocated spasmodically for several years. The literature on the subject is, however, very limited. For a number of years many surgeons have made use of the omentum to cover abraided peritoneal surfaces and to reinforce the suture line after closure of gastric and intestinal perforations. The reported cases are how-

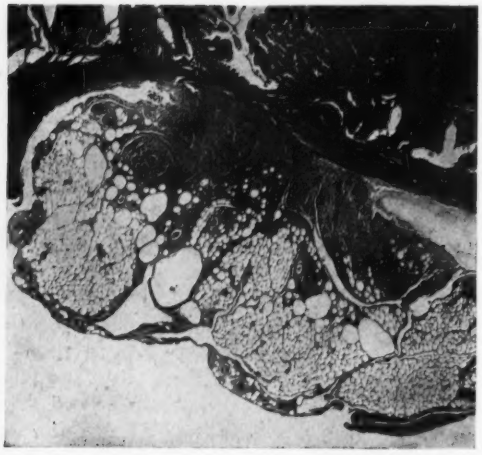


Fig. 1. Three months after implantation of free omentum over intestinal anastomosis made with single approximating suture. Omentum in direct contact with anastomosis has undergone fibrous change. Outer portion is practically normal.

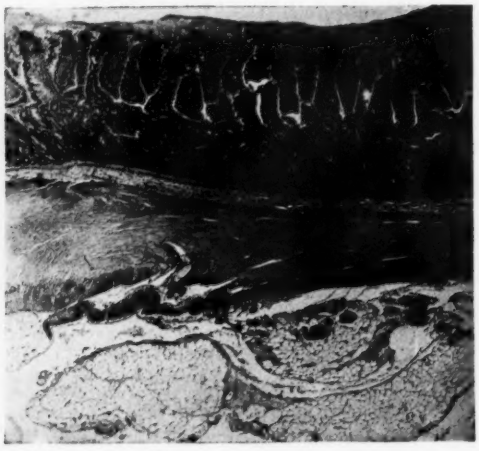


Fig. 2. Six months after attachment of free omental graft over suture line closing slit in intestine. No adhesions to suture line and graft has undergone very little fibrous change. Separation from intestine occurred during preparation of specimen.

ever, largely clinical and the ultimate fate of the grafts is unknown.

Binne recommends reinforcing the suture line with free omentum to prevent intra-abdominal hernia. He also suggests the use of omental grafts to cover the stump of fatty mesentery after the removal of large amounts of small intestine. In a case of duodenal perforation in which the opening could not be closed by suture, Clogg successfully covered it by attached omentum. Binne points out that a free graft would be preferable as the former might be the excuse for an internal hernia.

Warbasse recommends the use of both attached and detached omental grafts to strengthen intestinal suture lines. Fowler offers a similar suggestion and refers to the experimental work of the elder Senn who recommends scarification of the intestinal wall before application of the graft.

The value of the great omentum especially in constructive surgery is pointed out by Charles Mayo and the need of its conservation emphasized. He recommends its use to prevent or make harmless visceral adhesions; to cover denuded surfaces; to prevent union of stomach or duodenum with the liver after cholecystectomy by interposition and suture of omentum to round ligament; to cover damaged intestine; to reinforce suture lines and carcinomatous areas which are in danger of perforation from distention. He states that "free grafting of the omentum is a temporary patch which soon necroses and becomes absorbed after serving its purpose."

During the course of experiments to control postoperative adhesions, Sweet, Chaney, and Wilson applied free omental and free mesenteric grafts to the intestinal suture line in two animals. The autopsy one and two weeks after operation showed the grafts in place and free from adhesions.

The use of mesenteric grafts should not offer any greater difficulties than the use of omentum and in all probability would be found equally beneficial since it has two peritoneal layers. However, it should not be especially fat as the chances for necrosis would be greater. The use of mesenteric grafts would be slight since it is practically never available except after resection of the small intestine.

Two noteworthy papers on the subject of detached omental grafts have appeared. The first by Freeman is purely a discussion of the clinical use of omental grafts with mention of certain cases in which the author has made

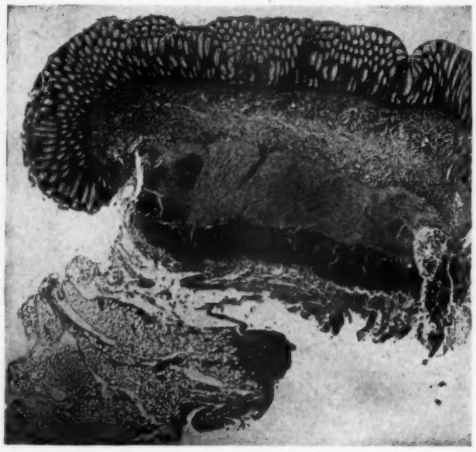


Fig. 3. Free omental graft sutured over puncture in intestine. Three months after operation. No closure of opening other than with graft. Some infiltration and destruction of graft due to infection of its inner layer by intestinal contents. Graft, however, survived and permanently closed opening.

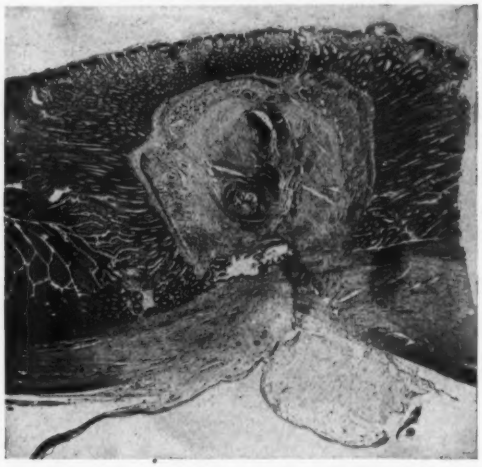


Fig. 4. Three months after suturing free omental graft over end-to-end anastomosis. Silk suture still in place in intestine. Graft has survived practically unchanged. No adhesions.

use of this procedure. There are no pathological reports and the evidence as to the advantages gained is apparently derived solely from the postoperative history of the patients. Freeman recommends, from his clinical experience, the use of free omental grafts to replace lost portions of peritoneum; to prevent adhesions; to strengthen suture lines in operations upon the stomach and intestine; to occlude the pylorus or intestine; and to check hæmorrhage from raw surfaces, especially of the liver, spleen, and pancreas. He states that the technique of omental grafting is simple, although certain precautions must be observed. In brief these are: The pedicle should not be puckered by the ligation. The free border of the omentum should be chosen with avoidance of large vessels. As little tissue should be sacrificed as possible. The graft should be sutured in place. The transplant must extend beyond the raw surface.

The article by Davis is devoted largely to experimental work. He transplanted free omental grafts to the stomach, intestine, liver, spleen, kidney, and bladder, to denuded areas of the parietal peritoneum, and beneath the skin. Davis also used it to check hæmorrhage in the liver, spleen, and kidney. Two microphotographs show the omental grafts in the spleen and liver. He states that the results in these experiments were excellent, the omentum surviving to a surprising degree and when used as a hæmostatic, the hæmorrhage ceased almost immediately. Grafts up to three inches in diameter were successful.

The work of Davis substantiates the contention of Freeman that free omental grafts survive at least under sterile conditions and that the omentum is a serviceable hæmostatic agent.

There are numerous questions, however, which have not been satisfactorily answered and we, therefore, present the evidence from our own experiments.

The object of the experimental work was to determine: first, what became of free omental grafts when placed on the intestine under sterile and under septic conditions. Second, the size, thickness, and vascular condition of the graft which would insure the best vitality. Third, the preferable method of its application to the intestinal wall to insure its vitality and prevent its displacement. Fourth, a method to prevent adhesions from adjacent intestines and omentum to the free graft. Fifth, in what surgical conditions

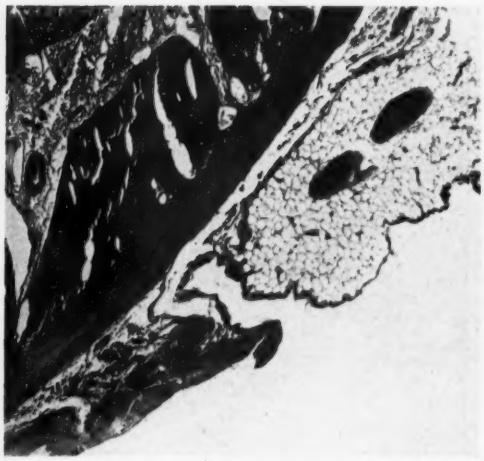


Fig. 5. Five months after implantation of free omental graft over suture line in artificial perforation of the intestine. Practically no change in graft due to absence of infection. Cells and nuclei appear normal. Adhesions absent.

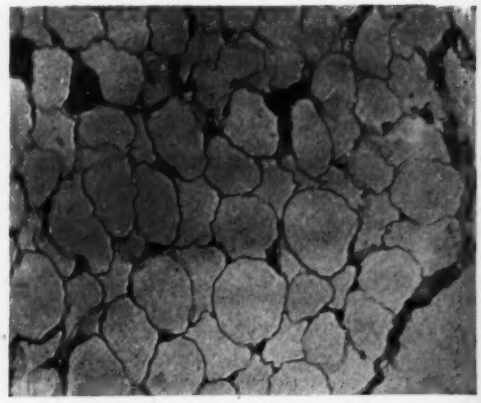


Fig. 6. Six months after implantation of free omental graft over suture line in artificial perforation of intestine. High power shows omental cells unchanged and nuclei living. Vessels contain normal blood. No evidence of necrosis, infiltration, nor fibrosis.

would the use of free omental grafts be justified, useful, or necessary.

The experiments were commenced in February, 1916, in the Department of Experimental Surgery, University of Pennsylvania, and completed at the University of Michigan. Dogs were used exclusively and all operations were performed under ether anæsthesia and strict sterile precautions.

EXPERIMENTS

SERIES I

a. To determine the fate of detached omentum and the proper size and thickness to obtain the best results when placed on uninjured intestine (aseptic conditions). Detached pieces of omentum were sutured to uninjured intestine under strict aseptic conditions and the animals killed by ether at periods varying from two weeks to six months. The size of the graft was carefully noted at time of operation and pieces of omentum of various sizes and thicknesses were chosen.

b. To determine if the vascular condition of the graft influenced its vitality. Exactly similar procedures were carried out with the single exception that the omental tag was doubly ligated before separation from the large omental sheet, the section being made between the ligatures, thus leaving the vessels of the graft filled with blood.

c. To determine whether abrasion of the peritoneum was a factor in the survival of the graft. Experiments similar to *a* and *b* were performed except that the peritoneal coat on the intestine was abraided. This was done by rubbing with dry gauze, by multiple fine punctures and by scarification with the scalpel.

d. To determine the best method for attaching the grafts. Omental grafts were sutured to the intestine with fine silks, with plain, iodine, and chromic catgut. The grafts were also sutured to the mesentery on each side of the gut around which the graft was placed.

SERIES II

a. To determine the fate of detached omental grafts under possible septic conditions. The intestine was punctured and the wound closed with Lembert sutures. A detached sheet of omentum was then spread over the suture line and fastened in place. Lateral and end-to-end anastomosis was also made and the suture line covered with omentum.

b. To determine the ability of the graft to prevent the spread of infection. Punctures of the intestine and end-to-end anastomosis were

made with a simple approximating stitch and the sutures reinforced with free omental grafts. Small punctures were also covered with grafts without any attempt to close the wound with suture.

SERIES III

To determine a method of preventing adhesions to the graft.

In all the experiments, the cut edges of the graft were carefully turned under but some adhesions still persisted, frequently to the free edge of the great omentum. In this series the grafts were either coated with vaseline, with paraffin oil, or were washed carefully with warm saline after being sutured to the intestine. The omentum was also carefully folded back and away from the grafts and in a few cases the greater portion of omentum was removed.

SERIES IV

To determine what structures are suitable for the application of omental grafts. Free omental sheets were applied after opening and suturing to the stomach, all portions of the intestine, the liver, the spleen, and the parietal peritoneum.

The microscopic sections were prepared by Dr. Lynne Hoag, the microphotographs by Dr. Frederick G. Novy.

RESULTS OF EXPERIMENTAL WORK

It was found that detached omentum survived in practically a normal condition when applied under sterile conditions to any abdominal organ. The size of the graft made no difference in its vitality. The thickness, however, is important. The thinnest grafts survived best and were least liable to favor adhesions. Thick grafts, especially those containing a large amount of fat were frequently the source of large adhesions and on microscopic examination, round-cell infiltration and loss of fat were noticeable. No difference could be determined between the grafts which were doubly ligated before attachment and those in which the blood escaped from the cut vessels.

Mechanical irritation of the peritoneal layer on which the graft is placed is not necessary. The vitality of the piece of omentum was equally good when the graft was placed on uninjured surfaces as when the area was rubbed, punctured, or scarified. Hæmorrhage under the graft, however, seriously impaired its chances of survival and seemed to favor the formation of adhesions.

Plain fine silk was found to be the preferable suture material. Practically no reaction was noted about the silk. This material can be tied in a very small knot and the ends cut close without danger of the knot untying. Plain catgut, size oo, is very good, but acts to a certain extent as an irritant. Iodine and chromic catgut are decidedly irritating and favor dense adhesions. At all times, an attempt was made to turn in all raw edges and to have the knot covered by the edge of the omentum.

Sutures must be placed at least at the four corners of the graft to prevent rolling. Suturing to the mesentery on each side of the intestine offers no advantages. In several instances, it seemed a disadvantage as the mesenteric attachment was the only seat of adhesions to the great omentum or the neighboring mesentery. It is not necessary to place numerous sutures; just enough to hold the graft in place is far preferable.

Detached omental grafts survived in every instance when used to reinforce Lembert suture lines when infection was kept at its minimum. When used to close small punctures and the cut edges of an anastomosis after a simple approximating suture the graft succeeded in preventing the spread of infection to the general peritoneal cavity. It did so, however, more as a mechanical patch, than as a living tissue, since the graft always showed marked pathological changes. The fat was largely lost and the whole mass densely infiltrated. It also was the seat of dense adhesions. The graft was undoubtedly of benefit, since a general peritonitis was prevented, but its action was only temporary and was supplemented rapidly by adhesions to the great omentum or adjacent intestine.

No method was found certain in preventing adhesions. The use of vaseline or paraffin oil increases their number and density. Washing in saline had no apparent effect

either to produce or prevent adhesions. The majority of adhesions to detached grafts was from the great omentum. Removal of the larger part of this naturally prevented these adhesions. The procedure, however, is not to be recommended for clinical use because the loss of so valuable an organ is not justifiable, and there is always a possibility of gastric hæmorrhages.

Detached omental grafts can be used successfully on any of the abdominal organs and on the parietal peritoneum.

INDICATIONS FOR THE USE OF OMENTAL GRAFTS

It has been found that omental grafts are valuable in the replacement of lost portions of peritoneum; to strengthen suture lines in stomach or intestinal operations; to cover over the stump of the cystic duct or to reinforce the bile ducts; to occlude temporarily the pylorus; to reinforce the peritoneum in threatened perforation from such conditions as mesenteric thrombosis, typhoid ulcer, or strangulated hernia; and to prevent adhesions by covering abraided peritoneal surfaces, such as occur after the separation of adhesions, the removal of tumors, or cholecystectomy.

Attached or detached grafts may be used for the above purposes. In the presence of peritonitis the detached graft will not survive, but may be used as a temporary mechanical agent, with the belief that adhesions will soon reinforce it. Detached grafts offer the advantage of being freely movable. They can be fixed deep in the pelvis, or up under the liver without any traction on the great omentum. The use of an attached graft means an adhesion to the part in every case while with the detached grafts many cases escape adhesions altogether. With the great omentum fastened to the intestine there always remains the possibility of a strangulation from a loop of gut slipping under the omental band. Such adhesions are also the frequent cause of abdominal distress.

Since the omentum practically always becomes adherent to damaged tissues and these adhesions are so frequently the cause of future trouble, the use of detached omental grafts, which in a large measure prevent the adhesions of the great omentum, is definitely indicated.

Occasionally we find the omentum while adherent to the injured gut has not completely covered the perforating area, allowing material to escape with localized or general peritonitis as the result. The use of detached grafts where threatened perforations exist is certainly preferable to trusting to the great omentum. In general such areas can be turned in, but occasionally, due to the great number of threatened perforations as in typhoid or mesenteric thrombosis, or where the area is extensive and the patient in a precarious condition, the use of detached grafts will be found of value.

Again, we find at autopsy some cases where the omentum has not become attached to the injured part. No one can foretell such a calamity and must guard against it.

TECHNIQUE OF USE OF DETACHED OMENTAL GRAFTS

The piece removed should be on the free border of the great omentum. The latter should not be markedly puckered and the cut edges should be covered. The graft must be thin, spread out carefully over the injured part, the cut edge rolled under, and fastened in place by several fine silk sutures.

CONCLUSIONS

The use of detached omental grafts is preferable to fixed grafts except in the presence of general infection. They may be used on any abdominal organ. The indications are to replace lost portions of peritoneum; to strengthen suture lines; to prevent adhesions; to check hæmorrhages; to occlude the pylorus; to cover the stump of the cystic duct or fallopian tube; and to reinforce the peritoneum in threatened perforations. The technique is simple and may be performed with little trauma and in a minimum period of time. In the absence of infection the thin graft survives at least 6 months practically unchanged.

REFERENCES

RUBIN, I. C. The functions of the great omentum. Surg., Gynec. & Obst., 1911, xii, 117.

BINNE, JOHN FAIRBAIN. Manual of Operative Surgery. 1916, pp. 404, 419, 445.

CLOGG, H. S. Brit. M. J., 1905, Jan. 2.

WARBASSE, J. P. Surgical Treatment. 1918, i, p.629.

FOWLER, RUSSELL S. Johnson's Operative Therapeusis, 1916, iv, 340.
MAYO, CHARLES H. The omentum, its physiologic values and need of its preservation. J.-Lancet, xxxvi.
Idem. Enterostomy and the use of the omentum in the prevention and healing of fistula. Ann. Surg., 1917, lxvi, 568-570.
SWEET, JOSHUA EDWIN, CHANEY, R. H., and WILSON, H. S. The prevention of postoperative adhesions in the peritoneal cavity. Ann. Surg., 1915, lxi, 297.
FREEMAN, LEONARD. The use of free omental grafts in abdominal surgery. Ann. Surg., 1916, lxiii, 83.
DAVIS, CARL B. Free transplantation of the omentum. J. Am. M. Ass., 1917, lxviii, 705.

THE FUTILITY OF BRIDGING NERVE DEFECTS BY MEANS OF NERVE FLAPS

By BYRON STOOKEY, A.M., M.D.[1]
Major, Medical Corps, United States Army; Chief of the Neurosurgical Service, Army General Hospital No. 2, Fort McHenry, Maryland

THE repair of nerve defects by means of nerve flaps has long been in use having been described by Létiévant in 1872 and by him first attempted in human surgery. His case was reported as a failure. The results in other cases have hardly been more encouraging. Most surgeons considered that this operation had long since demonstrated its inadvisability and had been definitely discarded. However, lately reference again has been made to this procedure as a valuable method in nerve surgery. In fact recently it has been warmly advocated by Mackenzie for the repair of nerve injuries in this war. He considers it regrettable that the wounded should be "deprived of its benefits" and "left to their fate." In order that this method of bridging nerve defects may finally either be justified or its real futility determined, this attempt is made to present the clinical, technical, and experimental evidence.

So far as I am aware the cases of bridging nerve defects by means of nerve flaps, central, peripheral or both, have never been collected.

In the literature there are several thorough collections of nerve suture without, howe[illegible] a critical review. Especially to be menti[illegible] are those of Woelfer, Huber, Spijarny [illegible]d more recently Coste. Spijarny assem[illegible]ed from the literature in all 192 cases and to those added 5 from the Moscow clinic. Powers, in his brief review, quotes Spijarny as presenting 11 cases of nerve-flap operation. This I was not able to verify. After carefully going over all cases recorded by Spijarny, only 5 were to be found. They are those of Létiévant, Tillmanns, Dittel, Brenner, and Gleiss numbered respectively, according to his table, number 16; 104; 184; 185; 188. Gleiss' case though a nerve flap was also tubulized and hence was placed by Spijarny under the category of tubulization.

To this list must be added the case of Bobrov, presented for the first time by Spijarny. In all, 6 cases of nerve flap are mentioned in Spijarny's article.

Powers' error may have originated from the review of Spijarny's paper, which appeared in the *Revue de Chirugie*,[2] in which the statement is made that the flap method of Létiévant was performed eleven times.

In Powers' article there are references to 11 cases of nerve flap operations, but with no attempt to give any definite data concerning them. One case, that of Neugebauer, though classified as a nerve-flap operation is not one. This error is probably due to the conflicting meaning the term neuroplasty has come to have. Neugebauer so designated the case though neither central nor peripheral flaps were used. Gleiss' case is also recorded as a successful flap operation in spite of Gleiss' statement that the case showed no evidences of regeneration.

To make this report more complete, it was thought best to review in the original reports the cases found in the literature from the first operation of Létiévant up to and including the year 1914. Sufficient time has not lapsed for those cases operated upon since 1914, to admit final judgment with justice

[2] 1895, xv, 857.

[1] On special detail in experimental nerve surgery under Dr. Huber, Director of Anatomy, University of Michigan.

to the method. Furthermore, since the war all of our former literature is no longer available. Hence for these reasons the cases have been investigated only up to 1915.

I am aware that some few surgeons during the war, when it was felt that something must be done to overcome the large nerve defects so frequently found, have attempted this operation in quite a series of cases. Gratzl performed flap operations in 8 cases on the German wounded. The distance bridged varied from 3 to 8 centimeters, the average being 4.6 centimeters. The average time between operation and publication of the report was five months—a period obviously too short to admit of any valuable deduction. Gratzl himself says: "The results after so short a time are not yet definite." These cases and others like them will have to be investigated later when final end-results are available.

It is unfortunate that some cases in the original reports could not be obtained. Some omission of cases, which should be included, however regrettable, would not be surprising in view of the difficulty in collecting them. An earnest attempt has been made; nevertheless, the list may not be complete.

It was at first planned to present them in tabular form, but this was deemed inadvisable in view of the great variation in the cases and the necessity of presenting more details than could be given within the limits of a table. Furthermore, it was felt that a brief résumé of each case together with a critical review, rather than a simple collection of the nerve-flap operations might be of greater service and enable more valuable deductions to be drawn. Thus the cases in place of being merely assembled have been submitted to a critical study in accordance, so far as their reports permitted, with the more recent advances in nerve surgery. By so doing it was felt that a more positive position might be taken in regard to bridging nerve defects by means of nerve flaps, particularly if to the clinical data were added the results of experimental evidence.

In the literature it is very evident that there is considerable confusion of terms, not only in our own language but also in French, Italian, and German.

The term neuroplasty has been used to designate operations by the method of anastomosis, by crossing, as well as by nerve flaps. In the German literature neuroplasty is also occasionally referred to as the Heuter-Zerny method, neither of which authors originated the nerve flap method. Since the term neuroplasty does not in itself designate any particular type of operation, it would, therefore, seem best to drop the word altogether and to indicate each operation by its own specific term, viz., nerve flap, etc.

Sherren pointed out the lack of uniformity of terms in English when compared with those in use by continental writers. He suggested that the word graft be altogether dropped since on the continent it is used in a totally different sense. However appropriate when Sherrens' suggestion was offered twelve years ago, at this time it might not seem advisable to omit this word so long in usage for other tissues. It designates to our minds a definite type of operation and is now universally so used by the continental writers, Duroux, Babinski, Dejerine, Nageotte and Gosset, etc. All of these speak of the *greffe nerveuse* to indicate a segment of nerve interposed between the severed nerve ends of a nerve trunk and no longer only for nerve implantation as was formerly the case.

The term graft is in conformity with long surgical usage to designate the removal of any tissue from one site to another.

In order that there may be greater conformity and perhaps less confusion, I would venture to suggest that the term neuroplasty be totally omitted; the term nerve graft as well as transplant be used to designate interposition of a nerve segment between the severed nerve ends of a nerve trunk. The graft naturally being further designated as autogenous, homogenous and heterogenous and also whether living or dead, fresh or preserved (cold storage, etc.). The rather recent extensive usage of the word transplant has given to it, perhaps a more definite place than graft and among most writers it will be given preference.

Sherrens' suggestions concerning further uniformity in nomenclature should be somewhat modified and more generally adopted.

Sherren has suggested that the term nerve anastomosis be used to designate the operation of nerve implantation, *greffe nerveuse* according to the method of Létiévant and the German *Nervenpfropfung*. He also includes under anastomosis the operation whereby a flap is raised from the sound nerve and sutured to the distal end of a severed nerve. From an anatomical standpoint this last operation is quite a different procedure. In this the severed end of the injured nerve is brought in direct apposition with the severed and cut end of the nerve flap in which there are severed neuraxes. Whereas, in the former operation of implantation either central, peripheral, or both, the severed ends of the injured nerve are implanted in a slit made in the sound nerve. Most often the slit serves only to separate the funiculi and does not cut the neuraxes except incidentally. The severed nerve ends come to lie between funiculi and not, in the main, against severed neuraxes as is the case when a flap is raised from a sound nerve and is sutured to the distal end of the injured nerve. Thus from the standpoint of nerve regeneration the term nerve anastomosis as suggested by Sherren would come to include two distinct surgical procedures.

It might tend toward a more definite conception of nerve repair were the operation above described, that is to say, the raising of a flap from a sound adjacent nerve and the end-to-end suture of it to a severed nerve be included in the division of nerve crossing.

Nerve crossing seems to me to be the most descriptive term in use. By it is meant the union, end-to-end, of the central end of one nerve with the distal end of another. This would be *complete* nerve crossing. When a flap is raised from a sound nerve and sutured to the *end* of another the operation should be designated as partial or *incomplete* crossing. Both procedures have the same anatomical basis and should be included in the same division.

It might then seem advisable since this operation is removed from the category of anastomosis and placed in the division of nerve crossing that in place of the term nerve anastomosis as suggested by Sherren the term nerve implantation be again used to designate the implantation into a sound nerve of either the central, peripheral or both ends of an injured nerve.

In résumé then the terms suggested are nerve graft or nerve transplant, preferably the latter, to designate the interposition of a nerve segment between the severed ends of a nerve; nerve implantation to designate the insertion of a nerve end, central, peripheral or both into a slit made into a sound nerve; nerve crossing complete or partial to designate the end-to-end union of a severed central end of one nerve to the peripheral end of another or the end-to-end union of the end of an injured nerve to a flap raised from the central portion of a sound nerve. The operation of nerve flap should be called nerve flap and not neuroplasty which term is too vague and general.

Perhaps no one case in the literature of nerve flap suture has been more extensively advocated in support of a continuation, if not a revival, of the nerve flap operation than the case of Mackenzie. Frequent references and quotations of it are to be found here as well as abroad. Binnie cites in his *Operative Surgery* the case, not merely, but the accompanying figures as well and thereby has lent, in a measure, support to this procedure, which it was thought had been shown to be of little value if not harmful. For these reasons among others the case merits a more thorough study to determine, if possible, what actually has been the end-results and what Mackenzie's reports have contributed to the advance of nerve surgery or if they have served to bring about a renewal of a method which should have remained definitely in the category of discarded surgical procedures.

Mackenzie in his last report makes an earnest plea for the use of this method. He says: "It is inconceivable that any other method . . . . . could have brought about equivalent results."

Studied from a critical standpoint there are certain facts in the papers of Mackenzie which should be examined more thoroughly before judgment is passed. If this case as reported will stand investigation, then the nerve flap method is revived, not only, but

the whole question of peripheral regeneration, which has long since been shown to have been *hors de combat.*

Mackenzie after removal of "10.75 inches of the sciatic *in toto* from the lower border of the gluteus maximus to 1 inch above the apex of the popliteal space . . . . . with every effort to preserve any visible branches," performed two successive flap operations; the first, 16 days after the original operation. "A flap 16.75 inches in length with its diameter *a shade less than half the diameter* of the internal popliteal," beginning at the level of the lower border of the internal malleolus to within a half inch of the divided end of the internal popliteal. Its end was then implanted in a "*slit* made in the stump of the sciatic nerve." By a similar method a second flap was made of the same length from the external popliteal.

Mackenzie reports that following the operation for removal of the tumor mass there was "absolute paralysis of the leg." It is presumed that the author does not include the thigh since there could have been no paralysis of the extensor quadratus, etc. No mention is made at this time of the state of the important muscles, namely, the biceps semitendinosus, semimembranosus, etc.

Following the removal of the cast after the first flap operation "about the tenth day . . . . . the leg could be very feebly flexed." Since this movement of flexion of the leg upon the thigh occurred 10 days after the operation, manifestly a time too early for any possible regeneration, it is but possible to conclude that the complete nerve supply to the flexors of the leg was not severed. It is well known that the nerve branches to the biceps and semitendinosus come off exceedingly high up in the thigh, in fact not in the thigh at all but in the gluteal region, higher than the line of excision of the tumor as given by Mackenzie, viz.: "at the lower border of the gluteus maximus."

According to Piersol there are two sets of branches to these muscles: "an upper set leaves the sciatic below the tuber ischii and sends fibers to the upper portion of the semitendinosus and long head of the biceps femoris." It is thus improbable in view of the line of excision that this supply to the flexors of the leg was severed. Mackenzie in the operative report makes no mention of having cut *these* branches, indeed "every effort was made to preserve any visible branches." It would be of value to know what branches in the thigh were saved.

It is only after making his clinical observation that it is stated that the branches to the flexors of leg were divided. It is entirely probable, judging from the anatomical position of the operation, that the *lower* and *not* the upper branches were severed. In this manner the voluntary power of "feeble flexion of the leg" ten days or thereabouts after operation can readily be accounted for by the remaining nerve supply to the semitendinosus, unsevered, and, to all probability, not even within the operative field. Hence, the fact that the patient is able to flex the leg upon the thigh cannot be offered later on, following the nerve flap operations, as evidence of nerve regeneration and restitution of function. At no time probably was there total loss of the power of flexion of these muscles. Again shortly after the second flap operation (no definite time is stated) it was manifest now that the "leg could be bent on the thigh with most freedom and energy" but it was noticed that there was "very little muscular power in the movement."

It has been a clinical observation by Jones, Stookey, Tinel, and others, in not one but many cases of sciatic injury, that the hamstrings escape injury, at least sufficiently to permit of some flexion of the leg on the thigh, due, no doubt, to the *double* supply of these muscles; the higher branches coming off before the nerve emerges into the thigh from under the gluteus maximus. Spijarny, commenting on a similar case operated upon by Bobrov in which 12 centimeters of the sciatic was removed, says: "On the twelfth day when the extremity was straightened the movements at the knee were performed almost freely—the *flexors contracted well.*" In this case he says: "It is necessary to note the rather quick recovery . . . . . and the appearance of function of the flexors of the leg, namely, biceps, semitendinosus and semimembranosus." This is another example of

extensive operation on the sciatic with retention of the upper group of branches to the hamstring and with power of contraction remaining in these muscles. Thus with retention of part of the nerve supply to the hamstrings the patients soon become accustomed to the paralysis of the lower leg, and are able to walk and even run with but little inconvenience other than foot drop. Therefore, to attribute as has Mackenzie "independent and unaided locomotion" as proof that regeneration has taken place is fallacious.

In order to determine in greater detail than is usually given on this point of some clinical importance, an investigation was made on eight sciatic nerves.[1] After exposing the gluteous maximus its lower border was determined. At this level, over the sciatic nerve, a heavy blunt dissector was inserted through the tissues marking the lower border of the muscle. The sciatic was then exposed from above downward in order to avoid stripping up the nerve branches. The point at which the upper group left the nerve to the hamstrings was then determined. In every instance it came off from the nerve at about the level of (in one instance 1 centimeter below) the tuberosity of the ischium and *above* the lower border of the gluteus maximus. In one instance it came off 6 centimeters above this level and in another 2 centimeters—the average being 3.5 centimeters above the gluteus maximus. The nerve is not really a branch of the sciatic but a separate nerve—the nerve to the hamstrings, which is described by Piersol, not under the heading of the sciatic nerve and its branches but under the muscular branches of the sacral plexus. The nerve lies in loose connection with the sciatic and may be readily separated from it for a considerable distance. This anatomical consideration may explain the frequency with which the semitendinosus escapes injury. Another point may be deducted, namely, that in operations in which the sciatic must be severed, even up to the sciatic notch, this nerve, at least its upper branches, may be saved and flexion of the leg rendered possible.

[1] I wish to thank Dr. McCotter for the generosity with wh'ch he placed the dissecting room material at my disposal and Dr. Guild for his kind assistance in helping me to make these measurements.

Thus the evidence in Mackenzie's case in support of regeneration following the nerve flap operation, enabling the hamstrings to contract, together with the appearance of "independent and unaided locomotion" is not beyond criticism and most certainly cannot be accepted as conclusive evidence in support of the nerve flap operation.

The remaining muscles to be investigated are the flexors and extensors of the foot concerning the paralysis of which there can be no doubt. Should these muscles show a return of function enabling the movements of the foot to be accomplished then the value of the nerve flap method in this case might be firmly established, or conversely its futility determined.

In his first report there was complete reaction of degeneration of these groups six months after the last operation. Mackenzie reports at this time "partial reaction of degeneration of the extensors of the foot and complete reaction of degeneration of the flexors of the foot." In the paper of October, 1918, more than ten years after the operation Mackenzie states "minute examination of these muscles show them to be strong and capable of contracting and while they do not move the foot they *control* it and there is but little tendency to foot drop. Some of the muscles of the group now show only partial reaction of degeneration." It is regrettable that no mention is made of the examination of particular muscles.

However, let us see what progress during these years this represents as compared with the examination made six months after operation. In the first report it is said that while these muscles "do not move the foot they control it, and there is no tendency to foot drop." Comparing these two reports there seems to be little discernible difference, mostly in favor of the report 10 years ago in which it is said there is "*no* tendency to foot drop" whereas, the last report shows but "*little* tendency to foot drop."

Physiologically it is inconceivable that muscles should be able to "control the foot" without having the power of contraction and without (in the absence of ankylosis, etc.) being able to move it. Professor Bobrov

commenting upon his case, so very similar in all its aspects, recognizes that because of the degeneration of muscles into connective tissue a more or less desired degree of diminished foot drop is obtained. His patient was able to walk "totally satisfactorily . . . . . ever since the operation the patient never caught the toe of his boot on the floor and did not experience any special inconvenience from his paralyzed foot." However, Bobrov did not attempt to attribute these results to any re-establishment of conductivity by means of the nerve flap operation but says that "it follows that the removal of the sciatic nerve for a great distance, even though *one does not succeed* in restoring nerve conductivity by a plastic operation does not necessitate the removal of the extremity."

From Mackenzie's own reports, both 14 months, and more than 10 years after the operation, these muscles are unable to "move the foot" yet Mackenzie states they "control it." If for so long a time after these two nerve flap operations there has been no return of flexion or extension of the foot, there is little or no evidence of motor recovery.

In résumé, on the motor side there are no acceptable evidences, judging by both reports of Mackenzie, of return of motor function of muscles unquestionably demonstrated paralyzed at the time of operation. The evidence in favor of this operation from the view of motor recovery is neither conclusive nor acceptable.

The sensory findings perhaps admit of less definite and final criticism, since unfortunately there is considerable variability in the method and manner of determining the limits of loss of the various forms of sensation. The personal equation may play a very important rôle. Anyone who has gone over carefully a number of nerve injuries will be aware of the many possible pitfalls and sources of error.

Mackenzie states that there is "recovery in a limited degree of protopathic and epicritic sensibility" and that "there is *almost* universal recovery of deep sensibility." The chart accompanying Mackenzie's last article shows the loss of sensation, if not identical, very similar in its boundaries to the chart ten years previous. It is a well-known fact that deep sensibility in total sciatic injuries, if frequently, not almost absent, is very limited. So constant was this variability in these cases that latterly I discarded it as evidence of comparatively little value. Mackenzie at his *original* examination states that even within the area of presumed loss of deep sensation, "there seems to be a remnant of response to the stimuli of deep pressure." However, epicritic and protopathic sensibility, i.e., the sensation to cotton wool, compass points and moderate degrees, pin prick and extreme degrees are of immense value.

The progressive shrinkage of their borders are of the utmost diagnostic and prognostic importance. Their return is apace and often in advance of any motor return. That their loss in this case more than 10 years after the operation should be "recovered . . . . . in a limited degree" is in keeping and harmony with the lack of motor return. In the original report years ago Mackenzie states "there is almost universal recovery of deep sensation . . . . . extensive development of protopathic sensibility" and "much recovery of epicritic sensibility." In the 1918 report, as stated above, there is recovery only in a "*limited degree* of protopathic and epicritic sensibility."

It would appear then that there is little change in the sensory status within the past 10 years.

Surely neither the motor nor the sensory evidence as reported by Mackenzie warrant the conclusion of "progressive regeneration" "on a colossal scale."

Further evidence in support of the nerve flap operation is offered by Mackenzie, which, if acceptable, revives the whole theory of peripheral regeneration and immediate return of nerve conductivity by primary union. Immediately following the union of two nerve flaps there is established according to Mackenzie "the transmission of a force which governs nutrition and greatly arrests trophic shock. The effect is almost *immediate* and very striking. They (nerve flap operations) also demonstrate that muscular tone follows *promptly* upon the splicing of a divided

nerve." Mackenzie states that bridging this large gap with a flap "would do good by *establishing* conductivity . . . " and again "implantation in the gap of a large nerve element to *establish a nerve path* and foundation for regeneration" and that "it tends to show that regeneration takes place from the peripheral as well as from the central end of a divided nerve" though "more recent studies would *tend to* confirm the principle" of regeneration from the central end. In no other way than by *immediate return* of conductivity could these phenomena reported by Mackenzie be accounted for.

On the tenth day after the first flap operation Mackenzie reports that "on removal of the cast the evidence of trophic disturbances were largely swept away." Within two weeks after the second operation there was "revealed marked improvement in the nutrition of the leg and all trophic disturbances seem to have cleared away except over the central part of the anæsthetic zone." Thus these changes occurred almost at once after the nerve flap operation. Ten years later "trophic recovery is practically complete," essentially the same remark as in his earliest report. In this respect as well as on the motor and sensory side the intervening years seem to have revealed very little if any progress.

Placing a limb at rest in a cast, thus maintaining it immobilized and protecting it from trauma, so potent a factor in the production of so-called trophic ulcers and blebs, etc., will, as is well known, greatly improve its condition and appearance. This improved condition may be further increased by massage and electricity which were given this patient. Under such treatment in complete nerve injuries, even before operation, I have repeatedly seen most marked improvement in the appearance of an extremity. To attribute these changes to an immediate establishment of nerve conductivity is obviously erroneous.

In Mackenzie's second case, also an excision of the sciatic nerve, two flaps from the central portion were made. About 8 inches were removed on account of scar tissue. Several operations had been performed due to the unfavorable conditions which had prevailed and over which Mackenzie had had no control. The wound previously had been seriously infected and the amount of scar was excessive. In order to obviate this, Mackenzie imbedded the nerve flaps *in* the adjacent muscles, forming a groove for them by means of a blunt dissector.

The report of this case was made two years after the last operation. One might, perhaps, by this time anticipate a certain degree of beginning regeneration. On the contrary "there has been no recovery of motion in the muscles supplied by the internal and external popliteal nerves . . . . . and the foot is still vulnerable in places." Notwithstanding these facts which indicate essentially no return of function, Mackenzie reports that "it is perfectly clear that extensive regenerative changes have taken place in the leg and that they are still progressive."

The only apparent improvement is that the patient can perform "locomotion over a distance of 4 or 5 miles without adventitious aid" and that there is "excellent control of the foot and leg on locomotion permitting only a very slight tendency to foot drop." The rather obvious deduction from such *apparent* power of locomotion is that there has been some return of motor contraction of the paralyzed muscles. This, however, has been not the case, according to Mackenzie, who states as above quoted that there had been no return. The same criticism holds here as in the first case, namely, that *total* movements which may be taken on by other muscles or which the patient can in a measure dispense with cannot be offered as *valid* evidence of nerve regeneration.

Certain technical points are raised in this case, which are worthy of attention. The passage through muscle of nerve tissue, especially when it is stripped or cut from the nerve trunk, i. e., having torn and rough edges, tends to increase the amount of scar tissue formed and may thereby endanger the downgrowth of neuraxes were these to reach the flaps. Placing nerve flaps or grafts in the smooth fascial planes *between* muscles, is an excellent procedure. *Surrounding* them with torn and naturally bleeding muscle fibers, as is done when a flap is pulled through

a tunnel in a muscle made by blunt dissection, is to be avoided.

The conditions found in this case, as to excessive scar formation are precisely the problems which present themselves in nearly all war wounds. And what in this appeared to Mackenzie as "grave and almost insuperable difficulties" to the success of the nerve flap operation are precisely the difficulties with which it would be necessary to deal in war wounds.

In Mackenzie's third case a flap of 1.5 inches was turned down from the central stump of the musculospiral nerve. The operation was done in the presence of some infection, apparently not any more than requiring a drain for 24 hours when it was removed and "the wound healed quickly thereafter," the patient regaining in 8 months control of her hand.

Here again in the end-results a total movement is offered as evidence of recovery. The father reports "eight months afterwards that the hand could be lifted from the wrist into its correct position and that within fifteen months this young woman was taking the massage course at McGill . . . ." The status of the individual muscles involved is not stated. Such data while satisfactory as criteria in many other surgical conditions cannot be accepted as scientific evidence in nerve injuries, and form a basis of recommendation for a given procedure in nerve surgery. The question is not, can the patient walk or move the hand, but *do* certain muscles which were demonstrated paralyzed again function? It is well known since Létiévant that many movements may be successfully imitated and although the movement is accomplished the paralyzed muscles may have played no rôle. "It is neither the movements nor the utility of the hand which should be investigated but the muscles;" a principle which formed the fundamental basis of Létiévant's teachings.

For example, complete supination may be simulated in total musculospiral paralysis by the action of the external rotators of the arm when the arm is moved as one piece. As pointed out elsewhere in median paralysis the patient may be able to flex the fingers with the hand in supination by quick extension of the wrist followed by sudden relaxation. Flexion of the wrist may also be accomplished by associated action of the extensors, which may lead, if a careful examination is not made, to erroneous conception of the muscles paralyzed. Even the finer movements of the muscles of the hand may be so well performed that considerable care is required to appreciate the difference. The action of the opponens pollicis may be so deftly imitated by the flexors of the thumb and adductors that one can with difficulty distinguish the difference, as Beevor, Claude, Duma and Forack pointed out that the thumb in an attempt to touch the fifth finger skirts the base of the fingers and does not openly cross the palm, but yet is able to reach the little finger—a movement very similar to true opponens action. If during the movement one feels at the base of the thumb, absence of contraction of the opponens muscle will be noted.

In ulnar paralysis adduction of the thumb, that is, movement of the thumb toward the index in a plane at *right angles* to the palm cannot be performed. But if you place your finger between the thumb and index the patient will be able to squeeze it quite tightly; an action resembling very closely that of pure adduction but accomplished by either the long extensor of the thumb or the long flexor. If in the effort the movement is accomplished by the extensor, extension of the whole thumb takes place and there is outward rotation; if by the long flexor, the distal phalanx is flexed and the surface of the thumb looks toward the palm. Thus many movements apparently under the control of a given nerve may still be accomplished even though the nerve is totally severed. I have frequently seen in nerve injuries such total movements performed in a most surprising manner, even writing and using a knife and fork, etc.; movements which require a certain degree of finesse.

From this and other cases to follow, it is obvious that there is great need for correct appreciation of the proper criteria and accurate evidences of beginning regeneration, progressive regeneration and completed regeneration. No case should be presented in

support of the successful employment of any given surgical procedure unless it falls into one of the above categories and is accompanied by the corresponding data essential to admit of determining the degree of regeneration. Were cases reported so divided and presented then the evidence offered would readily permit correct and valuable deductions.

It is well appreciated that in order to report end-results a period of years may be necessary. Hence the above classification would give an opportunity to offer from time to time various methods. In view of the rather experimental stage nerve surgery is recognized to be in at the present time, beginning and progressive signs of regeneration are perhaps of great value. End-results are obviously to be preferred. Charts and the electrical examination of each muscle or muscle group, both before operation and during the period following the operation, as well as individual muscular action rather than total movements should accompany the report of each case. It is distressing to investigate the published histories of so many cases only to find that the reports as stated are of little value since the accompanying data are deficient.

Technical considerations. Central flap. By splitting or cutting a flap from the central portion of the nerve a definite part of the down-coursing neuraxes are permanently destroyed; the number in proportion to the width of the flap. It has been argued by Stoffel that each funiculus has a definite course within the nerve trunk, extending from the plexus to its ultimate predetermined distribution in the periphery. If this be true, then by cutting flaps from the nerve trunk, we have irreparably destroyed these definite nerve paths and their regeneration is rendered impossible. In flap operations in which two flaps are made from one stump approximately one-quarter to one-third of the nerve is removed from each side. The damage done to the central nerve trunk, from which regeneration must take place, is then considerable.

More recent investigations of Langley and Hashimoto, and Heinmann would seem to controvert Stoffel's theory. These authors show peripheral nerves to possess a series of internal plexus with only definite nerve paths over extremely short distances. Were the flap cut from the area of a plexus, or central to it, greater damage would be done the nerve trunk, than if the flap were made below the plexus. In either instance considerable permanent longitudinal loss of substance ensues. The neuraxes centrally at the site from which the flap is cut, will continue to regenerate. The conducting paths having been removed, these regenerating neuraxes are then apt to grow out into the surrounding tissue becoming lost and dispersed. Or they may coil upon themselves and help to form a neuroma on the nerve trunk itself.

Thus if one-third to one half the diameter of the nerve trunk be cut as a flap, one-third to one half of the neuraxes are permanently eliminated and without the possibility of again reaching the distal stump.

Dittel and others thought by turning down a flap from the central stump that new neuraxes were carried across the defect and at the point of suture further growth of these neuraxes would follow. Such is not the case. The central flap, when cut centrally and turned down, is nothing more than a degenerated segment of nerve. Since the neuraxes within the nerve flap degenerate the only tissue bridging the nerve defect is the conducting paths, in which the neuraxes have undergone degeneration and the sheath cells of Schwann rapid proliferation; in short Wallerian degeneration, the same as occurs in the severed peripheral nerve. The central flap, though connected with the central stump, is bent down upon itself over its connection with the central stump and thereby really offers very slight opportunity for the downgrowing neuraxes to make their way into the conducting paths. Thus these paths within the flaps, mechanically are so placed that they do not come in contact with the severed neuraxes; they being practically unable to reach them. Hence, the flaps do not serve the purpose for which they were intended. Furthermore, they inflict permanent damage to the nerve trunk.

Peripheral flap. Flaps cut from the distal stump deprive the peripheral nerve of a

definite portion of its conducting paths. In Mackenzie's case a flap was turned up from both the internal and external popliteal, 16 inches long and "a shade less than half its diameter." By so doing he removed permanently, from the normal distribution of these nerves in the leg and foot, the possibility of regeneration in the area to which their funiculi would have gone. A still greater damage is done by severing numerous muscular branches from the nerve trunk. One need only recall the anatomy of the external popliteal, etc., and especially the numerous muscular branches which lead from it, to realize the extent of permanent damage which is done by the formation of such a flap. When a branch from the nerve trunk to the muscle is thus removed and taken altogether from out of the field, the downgrowing axes are deprived of the possibility of a *path* from the remaining nerve trunk to the muscle. This is an extremely important point. Even were regeneration to take place and neuraxes grow down into the distal segment they would find no *paths* from the nerve trunk to the adjacent muscles. The muscles thus severed from their nerve branches would remain permanently without the probability of neurotization. It is of course obvious that the peripheral flap is also a degenerated nerve segment, the same as is the distal segment from which it is cut.

The method of uniting the central or peripheral flaps into either the peripheral or ventral stumps would be of some importance if the flap method were of value. The severed end of the flap should be brought into apposition with the refreshened central or peripheral end in order that the downgrowing neuraxes might come in definite contact with the conducting paths offered in the flap. "To insert the flap into a split" in the central or peripheral stump merely places the proffered conducting paths *between* funiculi which are pushed aside. The end of the flap abuts in the perineural connective tissue and does not come in contact with the severed neuraxes. For proper downgrowth the severed neuraxes should lie in as close contact as possible with the conducting paths of the flap used to bridge the gap. Unless this is accomplished they become lost and dispersed in the surrounding connective tissue. Thereby, the number of available neuraxes, already reduced by formation of central flaps, is further diminished. Even the remote possibility of a few neuraxes finding their way down these flaps is removed by such a union. This is the method of union Mackenzie employed.

The use of nerve flaps to bridge defects is based probably upon the close resemblance in its gross appearance of a nerve trunk to a tendon. Bridging defects in tendons by means of flaps is well founded because histologically the tendon is made up of one tissue—the densest variety of white fibrous tissue. It is a unit in itself. Healing by primary union establishes complete anatomical continuity. On the other hand a nerve trunk while grossly similar in its appearance, histologically is made up of two distinct elements: the conducting tubes and the neuraxes whose origin is in the anterior horn cells or spinal ganglia and which by growing out from the center come to lie within these tubes. Severed neuraxes must grow down from the central stump. The sheath cells of Schwann united to form syncytial strands serve as conducting paths. Then when two flaps are brought together union takes place automatically similar to a tendon, but neurotization does not obtain until the central neuraxes have grown into the distal stump.

These considerations are in part the answer to Mackenzie's query: "Why should a different law apply to the nerve than to the tendons . . . . ?"

From this it will then be seen that flap operations, either central or peripheral, cause permanent and irreparable damage to both the central and peripheral nerve ends. That degenerated nerve segments are utilized in both instances. That the possibility of offering conducting paths to the severed neuraxes is almost entirely negligible. That immediate union cannot establish conductivity. Hence, on purely *a priori* considerations in view of our knowledge of nerve regeneration and the histology of the nerve trunk operations by means of nerve flaps little hope is offered for the efficient regeneration of the function of the nerve.

Experimental evidence. The above conclusions are ably demonstrated by the experimental work of Huber. Seven flap operations were performed on the ulnar nerve in dogs. By means of both central and peripheral flaps defects were bridged varying from 5 to 6 centimeters. The animals were killed at intervals up to 147 days; one on the sixty-fourth day and one on the hundred and forty-seventh. Thus both late and early stages of repair were investigated.

When examined both physiologically and histologically in no instance were any evidences of regeneration found either within the flaps or the distal portion of the nerve trunk. "In sections through the region of the down turned flaps the collapsed sheaths, containing a small amount of nucleated protoplasm, were found. In these no evidences of regeneration were seen."

Because of a continuation, perhaps, of blood and lymph supply to the flaps, Huber found that they underwent degeneration somewhat slower than a free transplanted nerve segment. The rate of degeneration of the flap was the same as that found in the peripheral portion of the divided nerve.

Clinical evidence and critical review. A brief résumé has been made of each case. In the histories certain parts will be found in quotation marks the meaning and importance of which were such that it was thought best to quote the exact words. A few phrases within the histories the author has placed in italics and they are here acknowledged.

Mackenzie's case has been discussed in detail earlier in the paper and will not again be quoted. I would refer the reader to a *comparative* study of both of his articles.

Neugebauer reports the cases of nerve surgery between the years 1886-1895 from Wollfler's clinic. Case 5 in his series has been referred to in the literature as a nerve flap operation and by Neugebauer is called a neuroplastic. Instead of being a nerve flap operation one of the branches leaving the peripheral end of the radial nerve was used. The length of the defect bridged is not mentioned. At the end of the month the patient was lost sight of.

The case does not concern this report and is only mentioned that it may not again be referred to as a nerve flap operation. As previously mentioned this error probably occurred due to the various meanings the term nerveplastic has come to have. It indicates the advantage of using the specific term for each operation rather than one which has come to indicate almost any type of operation for nerve repair.

Similarly Giordano's report cited in Chipault, *l'etat actuel de la chirurgie nerveuse*, will not be quoted. Giordano bridged a gap in the vagus by means of nerve flaps. The case showed vagal symptoms and died at the end of a year with recurrence of the tumor, for the removal of which the operation was originally undertaken. The great difference in the more usual clinical manifestations of the vagus as compared with the other nerves under discussion would make a critical review of questionable value, especially in view of the indefinite report of the symptoms.

CASE 1. Reported by Létiévant (27). Soldier 24 years old on January 18, 1871, received a grenade wound on the inner side of his right arm. There was considerable laceration of the tissues and the median and ulnar nerve ends were seen separated from each other about 5 centimeters.

A few months later the patient came to Létiévant's clinic at Lyon. The wound was healed. There was complete paralysis of the median and ulnar nerves. This might readily have been overlooked had not a precise examination been made. The patient was able to hold his hat and to carry a glass of beer to his mouth. All fingers could be moved in both extension and flexion, also extension, flexion, adduction and abduction, supination and pronation of the hand. Electrical examination alone established the diagnosis. The patient was treated at first with electricity.

Operation March 13, 1872, fourteen months after injury. The nerve ends were separated 4 centimeters. After freshening the ends both central and peripheral flaps were made from the median and ulnar nerves. On the fifth day the wound was infected and on the forty-fourth day, April 27, 1872, the wound had healed and the patient left *Hotel Dieu*. On June 3, 1872, 82 days after operation the patient was seen for the last time. No improvement in the condition was found.

This is the first case of nerve flap operation in human surgery. Because of the ability of the patient to perform to a surprising degree total movements, Létiévant elaborated his theory of *motilité supplées*. It is unfortunate that this case was lost sight of and further reports were not possible. However, it illustrates admirably that the performance of total movements can not be taken as evidence of nerve regeneration for in this patient it was shown that these movements could be accomplished even before the nerve flap operation.

The case of Tillmanns has been generally cited as the first successful nerve flap operation performed in human surgery. In view of the excellent results obtained in this case Tillmanns recommended this procedure as a method for bridging nerve defects.

CASE 2. Reported by Tillmanns (42). Twenty-three-year-old girl on July 15, 1882, received a cut across the volar surface of the forearm three fingers breadth above the wrist. The wound healed after several weeks of infection. Following the healing of the wound the right hand was completely useless.

The beginning of November, three and one-half months after injury, the patient presented herself in the clinic. The hand was then held in a characteristic claw position. There was marked atrophy of the interspaces and both thenar and hypothenar eminences. Active motion of the fifth finger was impossible. Flexion of the first and extension of the second and third fingers could not be accomplished. Movements of the thumb with the exception of slight degree of abduction were deficient, especially addution, flexion and opposition. Because of scar tissue, flexion of the wrist was also impaired.

Electrical reaction was present in flexors of the thumb, finger and wrist. No reaction in the smaller muscles of the hand in the area of distribution of both the ulnar and median nerves. Every quality of sensation was lost on the palmar surface with the exception of the radial side of the thumb. Total paralysis of the median and ulnar peripheral to the site of injury.

"*Extension of the hand and fingers was somewhat hindered by the scar contraction of the volar surface.*" Supplementary movements as described by Létiévant were not present in this case "*probably as a result of the scar-tissue formation.*"

Operation November 14, 1882, four months after injury. The nerve ends were imbedded in scar tissue, particularly the peripheral stump. The central end was enlarged. The nerve ends were laid free and freshened. Four and one-half centimeters separated the nerve ends of both the ulnar and median. Even by marked flexion at the wrist, the ends could not be brought together. Flaps were made from both ends of both the ulnar and median nerves.

"The superficial and deep flexor tendons were grown together in a firm tendinous knot. The tendinous knot was first split horizontally so that the deep and superficial flexor tendons were freed from each other. Then the tendons for the respective fingers were separately freed."

Fourteen days after operation passive motion of the hand and fingers, massage and daily electrical treatment was given. Four weeks after operation some "improvement of sensation" was noticed. "Pin prick in the whole area of both nerves was felt as dull and in part were properly localized."

"Motor paralysis was not now the same as before the operation." Massage and electricity were energetically carried out. Sensation slowly and continually returned.

January 20, 1883, nine weeks after operation a certain degree of movement of the fingers was noticed in the area of the ulnar nerve. From this time on the patient constantly improved. By the end of February, 14 weeks after operation she had so much improved that she was able to pick up and hold tightly a pen, a drinking glass, etc. The sensibility at this time was nearly normal except over the tips of the second and third fingers. Movements of the hand and the fingers continued to improve, especially separation of the fingers. In November, 1883, one year after the operation, the patient wrote that she was again able to use her hand for all work almost as good as the left hand and that every movement of the fingers was good. Only sensation on the tips of the second and third fingers was not quite normal.

This case is quoted rather extensively because it is frequently cited in support of the nerve flap operation, being considered successful. There are two distinct pathological conditions presented. Both of them have to do with the motility of the hand and fingers, but each has a separate and distinct causative factor.

Tillmanns in the operative report gives an excellent description of the fixation and subsequent freeing of the superficial and deep flexor tendons. There can be no question that a great part of the impairment of motion in the fingers and hand must be attributed to the imbedding of these tendons in scar tissue.

From the site of the injury three fingers' width above the wrist, it is obvious that the nerve supply to the flexors of the thumb, fingers and wrist could not have been involved at this level. However, with complete severance of the median and ulnar nerves, all of the *intrinsic muscles* of the hand would be deprived of their nerve supply. Tillmanns describes total atrophy in this area.

Nine weeks after the operation Tillmanns reports "a slight degree of active movement in the fingers in the area of the ulnar nerve." The patient was able to perform such total movement as picking up a glass, holding a pen tightly, etc. These movements involve rather the muscles of the tendons freed from the scar tissue than the intrinsic muscles of the hand. One year later the patient writes that the movements of her fingers and hand are in every way free.

Tillmanns describes 9 weeks after the operation some improvement in adduction of the fingers as evidence of nerve regeneration.

Separation of the fingers in the presence of an ulnar nerve lesion can be extensively imitated by the extensors. Great care must be exerted to appreciate such supplementary movements, so adeptly are they performed. In a previous article I cited 3 illustrations to show the degree of separation possible due to the action of the extensors in the presence of an ulnar nerve lesion. Attention was called to the fact that the action of the interosseii can be better determined if the forearm be placed upon a flat surface up to the metacarpophalangeal joints, then holding the fingers flexed at right angles over the edge, to prevent the patient from extending them. The patient is then asked to separate the fingers gently and *without effort*. If the ulnar nerve is paralyzed adduction of the fingers will not occur. However, if the fingers be held straight, marked separation may take place; by the action of the extensors adduction may even be accomplished with the hand in the above position if the patient forcibly attempts the movements—the extensors being thereby brought into play. By this simple means the more marked action of the

extensors is thrown out, and the paralysis of the interosseii may be readily demonstrated.

In the pre-operative examination Tillmanns reports extensively the individual muscular action and electrical examination. It is regrettable that following the operation equivalent examinations were not made and that in place of reporting total movements individual muscular action was given. Had this been done there would then be no doubt as to the results.

It is submitted then in this case, so frequently reported as successful in support of nerve flap operations, that two distinct procedures were involved. One, the formation of nerve flaps to bridge the defect in the median and ulnar nerves. Second, freeing of the deep and superficial flexor tendons from dense scar tissue which had bound them into a "tendinous knot." It seems more probable that the total movements described both by the patient and Tillmanns are rather to be ascribed to the freeing of the tendon than to the bridging of the nerve defect. Even the slight increase of adduction of the fingers noticed by Tillmanns could be readily attributed to the action of other muscles, the movements of which were now freed by the liberation of their tendons from the scar tissue.

CASE 3. Reported by Dittel (12). A young girl twenty-two years old on December 8, 1890, was caught in a washing press and received an extensive ragged wound of the right arm about 15 centimeters long and 7 centimeters wide. About 7 centimeters above the internal condyle the peripheral ulnar stump was seen; the central stump was not found. It was estimated that at least 5 centimeters must have separated the ends. Sensibility and motility in the ulnar nerve area were absent. The wound was cleaned and an antiseptic bandage was applied. When seen on the following morning sensibility in the ulnar nerve area had returned and remained throughout.

The only difference in motility between the right and left hand was that flexion of the proximal phalanx of the fifth finger was normal; in the remaining phalanges less so. She was unable to squeeze as strongly with the fifth finger as with the other hand.

January 11, four weeks after the injury the granulations were deemed fit for skin graft and both skin graft and repair of the ulnar nerve were undertaken. The nerve ends were found separated approximately 9 centimeters. The central end was enlarged and the peripheral was very much smaller and showed no visible evidence of degeneration. A flap 7 centimeters long, half the diameter of the peripheral stump, was raised and a flap 1.5 centimeters long from the central. They were united with catgut.

In order to cover the wound a skin flap was made which later partially sloughed. On March 5, 73 days after the operation electrical examination gave negative results. On March 21, electrical irritability had returned.

It was thought that by turning up the nerve flaps the conduction might be reversed, that is the centrifugal becoming centripetal and *vice versa*, especially so since the axes cylinders in both flaps remained unbroken.

Dittel explains the apparent abnormal retention of sensibility by anastomosis of the sensory nerves of the skin in the upper extremity. At the time of this report the work of Sherren, Head, and Rivers distinguishing the various forms of sensation had not yet appeared. We do not know in this case whether the more superficial types were investigated, particularly touch, or if deep sensibility by means of pressure was tested. Deep sensibility is the usual form of sensation tested when slight pressure is made on the part, such as squeezing or by pressing with the pencil point, etc. This is done by some, thinking that they are testing tactile sensation, whereas, in reality such a method of examination calls into play a totally different mechanism. In the upper extremity deep sensibility is very seldom wanting except over very small areas in any *single* nerve lesion.

Dittel's attempt to explain the first electrical examination following the operation on the grounds that the axes cylinders in flaps remain unbroken and that there might thus occur a reversal of the current is obviously erroneous. We know that the axes cylinders of the central stump become degenerated when they are cut centrally and turned down and that those of the peripheral stump undergo degeneration the same as the peripheral segment.

In the examination a little over 2 months after the operation Dittel does not mention what muscles showed electrical response. No mention is made of the smaller muscles of the hand, so important an index of ulnar nerve function. No reference is made following the operation of any sensory examination. Without this data it is impossible to consider this case as successful. Dittel recognized, however, that insufficient time had elapsed and that it would be better to await a longer period before considering it a success.

The case lacks in a marked degree sufficient data to warrant the assumption that any regeneration has taken place and must be placed in the category of premature reports.

CASE 4. Reported by Brenner (5). A nerve flap operation was performed 10 years after the original injury. The patient came to the clinic on account of ulcers of the leg. As an associated finding a median nerve injury was discovered. The patient stated 10 years previously that he received a knife wound at the level of the wrist. Occasionally pressure over the site of the injury caused pain. At the time of examination the patient's second and third fingers were usually held flexed at the metacarpophalangeal joints, though the tendons and joints functioned normally. The skin of these two fingers was bluish in color and the fingers were distinctly more slender than the corresponding ones of the other hand. The nail of the index finger was thickened and curved. The palmar surface of these two fingers and the ulnar side of the thumb showed anæsthesia to pinprick, whereas over the rest of the hand the sensation was normal.

On June 18, 1889 the patient was operated upon. A large neuroma was removed from the central stump; the distal was found lying between the tendons beneath the ligamentum carpi transversum. With the wrist *extended* the nerve ends were separated by 4 centimeters. A flap 4 centimeters long from each end was cut, using one-half the diameter of the nerve. A flap was made on the ulnar side of the central stump and the radial side of the distal stump. Each flap was then sutured to the severed nerve ends. The hand was held in extension.

Two weeks after the operation complete sensation was restored in the formerly anæsthetic area of the skin. The patient left the hospital July 27, 1889, completely cured.

The patient was again seen one year later. At this time sensibility was *still* normal. The second and third fingers were no longer held in flexion and participated in all movements of the other fingers. The atrophic changes still remained.

In the pre-operative examination no mention is made of the movements of the muscles of the thumb. From the site of the lesion it is probable that only those fibers to the muscles of the thumb, the two radial lumbricales and the sensory fibers were severed. The description of the position in which the fingers were held, the appearance of the skin and the tapering of the fingers, together with the changes in the nail correspond to the picture often seen in incomplete median lesions at this level.

Brenner reports two weeks after the operation complete return of the sensation in the formerly anæsthetic area. We know that immediate return of sensation can not take place even in a primary suture in which the peripheral neuraxes have not yet undergone degeneration. In a secondary suture, undertaken within a short period after injury, at a time when there is active proliferation of the sheath cells of Schwann and according to some the presence of neurotropism immediate recovery does not take place. In this case the peripheral segment had been severed from the central for 10 years. In it there was no doubt considerable increase in connective tissue, the sheath cells had ceased to proliferate and there would likely be no neurotropism to guide and stimulate the down-growing neuraxes. Hence, such data as evidence of regeneration following nerve flap operation, in view of our present knowledge, can not be accepted.

The examination a year later gives no further indication of advanced or advancing regeneration. At this time trophic changes still persisted though these are usually the earliest to disappear.

The fact that the patient held the second and third fingers flexed at the metacarpophalangeal joints and that they now participate in all movements of the fingers offers no evidence of regeneration since the median supply to the flexor muscles comes off long before the nerve reaches the wrist. It is regrettable that this case is inconclusive. It rather tends to show that at the end of one year regeneration had not taken place.

Gleiss reporting the cases of nerve suture from Bruns' clinic from 1882 to 1891 presents 11 cases; thirteen nerves were sutured. In one case only was a nerve flap done.

CASE 5. Reported by Gleiss (14). A young boy 8 years old reported to the clinic November 10, 1887, 15 months after the original injury. He presented an old scythe wound of the left arm which had healed without surgical assistance.

Examination showed marked atrophy of the forearm and hand. Adduction of the thumb was impossible, flexion at the metacarpophalangeal joints was impossible. Flexion between the first and second phalanges was possible. The hand was a typical claw hand with marked atrophy of the muscles. The musculature of both the median and ulnar nerves did not respond to the faradic current. Sensation was everywhere present. The skin was bluish red and shiny.

On February 18, 1888, approximately 17 months after the original injury, an operation was performed on both the median and ulnar nerves. Considerable scar tissue was present in which the nerves ends were imbedded. The median was sutured end-to-end.

The ulnar nerve ends were separated by 10 centimeters. The central stump had retracted and was lying near the axillary space. After some stretching and freeing a 10 centimeter flap about one half the diameter of the nerve was brought down from the central stump and sutured to the distal end with four catgut sutures. At the point of suture the nerve was placed in a decalcified bone tube.

On July 13, 1888, a second operation was performed on the median. Nothing was done to the ulnar.

In March, 1890, one year 8 months after suture the hand was still held in a claw position. The ulnar musculature of the hand showed atrophy. The hand was bluish red, shiny, and the last three finger tips were slightly œdematous. Flexion and extension of the index finger were accomplished, "only the index finger could not be completely extended, the 3 remaining fingers were held contracted at the second interphalangeal joint and could not be extended." Passive extension was possible. The ulnar musculature did not react to the faradic current. The nerve trunk did not respond to galvanic. The small muscles of the hand showed anodal closure-contraction. Sensibility in the ulnar area was almost totally lost. "From the foregoing remarks it was shown that the ulnar nerve has not healed."

Gleiss' report is fairly complete and his conclusion that *regeneration has not taken place* in the ulnar nerve is entirely substantiated by the report of his finding. Powers unfortunately cites this case as a "successful neuroplasty of the ulnar." It is difficult to determine what rôle may have been played by the presence of the decalcified bone. The median nerve was sutured end-to-end, and it showed some improvement.

The case of Professor Bobrov, of Moscow, is extremely instructive and interesting. Spijarny, assistant in the clinic of Bobrov, presents the case together with four others in his extensive review of 192 cases of nerve suture and gives details concerning the case which do not appear in Bobrov's later report in the same journal. Powers, in referring to this case of Bobrov, was unable to give any complete data concerning the case since it was published in Russian and was inaccessible. In order that this case may be available in the English literature it was thought advisable to quote *in toto* the case history as reported by Bobrov, and in addition quote from Spijarny those details which are not given in Bobrov's report.

CASE 6. Reported by Bobrov (4). Daniil F., occupation night-watchman, entered the clinic September, 1893. On the posterior surface of the left thigh there was a swelling, occupying the whole space from the subgluteal fold down to the popliteal space. The swelling was regular and egg-shaped, solid, elastic and everywhere of the same consistency, slightly movable, and not attached to the bone. The

posterior surface of the thigh was covered with scales of epidermis and in some places there were pustules. The swelling was painless. It interfered with walking and sitting only because of its weight. All the movements of the affected extremity were performed but it was noted that there was a certain decrease in sensation of the leg and foot. The swelling according to the patient, is about of 30 years' standing. At first it was small, and then, especially in the last few years, the growth has markedly increased.

October 6, 1893, I performed an excision of the tumor. The tumor proved to be sharply bounded and enveloped in a solid connective-tissue sheath. It originated seemingly from the sciatic nerve, the latter was firmly adherent to the center of the tumor near its inner surface and the flexor group of muscles were slightly moved apart. In order not to leave part of the tumor, I had to cut out both the tumor and the whole trunk of the sciatic nerve over an extent of 12 centimeters. After removal of the tumor a plastic operation on the nerve was performed, turning back 4 and 8 centimeters from either end. Transverse incisions were made into the nerve trunk up to half of its diameter and from here the ends of the nerve trunk were split longitudinally to within 0.5 centimeters of the nerve ends. Nerve flaps thus formed were thrown against each other and the ends sutured together with catgut. The wound was sutured without drain. The extremity was flexed at the knee, in order not to stretch the sutured nerve. Over an aseptic bandage a plaster was placed.

The microscopical examination showed the new formation to be "fibrosarcoma myxomatodes;" the nerve fibers were separated by richly growing connective tissue.

On the day following the operation it was found that there existed a paralysis of movements and sensation in the whole foot, and also absence of response to electrical stimuli of the muscles of the leg. The wound healed by primary intention, twelve days after the extremity was extended. On the twenty-fifth day the patient was allowed to walk. During his further stay in the clinic although massage was used, there was noted a slight foot drop.

The patient began to walk pretty well, but he had to raise his left foot higher, because the foot on account of its weight hung down. On moving the extremity forward the toes dragged on the floor. Thinking that afterward the foot drop might increase, and that the movements would be materially hindered I offered to perform another operation upon the right ankle in order to obtain an ankylosis of the ankle-joint. The patient did not permit the operation, and as it has shown now (one and a half years after the operation) our fears were unfounded.

At present the patient is able to use his extremity totally satisfactorily. He walks better than last year, the foot on raising and moving the limb hangs down very little. Ever since the operation the patient has never caught the toe of his boot on the floor and has not experienced any special inconveniences from his paralyzed foot. In October he noted on the plantar surface of the heel a small suppurating surface, which made him come again to the clinic. Here we found a trophic ulcer about the size of 3 kopeks covered with weak granulations. The whole foot with the exception of a small part on the posterior and inner surface where the long saphenous ends, is insensitive; on the leg just above the ankle (and higher up) the sensation (pain and touch) is preserved. While walking the patient does not feel the ground and it seems to him that he is resting on the end of his leg. The muscles of the leg do not respond to electrical stimulation. The size of leg and foot is at present just the same as last year and the leg is bigger on the affected side.

MEASUREMENTS OF FOOT AND LEG

	Affected side	Normal side
Upper one-third	35.5 centimeters	34 centimeters
Middle one-third	29 centimeters	25 centimeters
Lower one-third	24.5 centimeters	22 centimeters
Foot in middle	26 centimeters	24 centimeters

On superficial examination there is evidence that the subcutaneous cellular tissue is infiltrated; the infiltration is solid, resembling such as we meet in old ulcers of the leg or in the primary stages of elephantiasis. In discussing this case I recall a case of the traumatic trophoneurosis of the lower extremity concerning which I made a report to the Surgical Society in 1890. (See the *Annals of the Surgical Society*, 1890, No. 4.) There we noticed in the patient, who was a laborer, that after a traumatic lesion of the nerves of the sciatic plexus (which took place 12 years before) a considerable paresis of the internal popliteal nerve and a "*mal perforant du pied*" which was present for the last two years. Together with the ulcer there was an increase in growth of the subcutaneous connective tissue of the foot (a microscopical examination of the removed foot was made) and an hypertrophy was found, partly on the leg and the tibia. All this seemingly depended upon a trophic derangement of traumatic origin.

Here at present we also see the increased density of the subcutaneous connective tissue and probably degeneration of the muscles into connective tissue, which even now puts conditions to the desired degree of immobility at the ankle-joint. Thus the paralyzed foot proves to be a mighty good support in walking. As further treatment it is necessary to teach the patient to look after his foot, so that ulcers will not be formed as a result of excessive pressure or dirt; in case they should appear, to treat them immediately so as not to lead to the formation of a deep perforating ulcer as occurred with the laborer.

In the literature I found a case similar to ours, by Trélat, 1875, where also a fibromyxoma of the sciatic nerve in a young man was removed as well as 15 centimeters of the nerve. Half a year later the patient was presented before the Surgical Society of Paris, and attention was called to the fact that the patient was able to walk fairly well. In this patient the early atrophy of the extremity was noted and also drop foot and an increased scaling of the skin.

Exactly similar cases were described by Marchand, Bouilly, and Bardenleben.

From this it follows that the removal of the sciatic nerve for a great distance, even though one does not succeed in restoring nervous conductivity by a plastic operation, does not lead to the necessity of removal of the extremity, because after all we get an extremity fit to use.

To this report should be added the additional details given by Spijarny.

After the operation there was complete paralysis of the foot. The sensation in it was only preserved in the part supplied by the saphenous nerve. On the following day drop foot was found. After the third day shooting pains appeared in the foot, referred to the toes. Sensibility was without change. On the sixth day was noted that sensation had returned in the whole foot with the exception of the volar surface of the big toe and the remaining toes. Sensibility in the leg then appeared. "After 12 days, when the leg was finally extended the movements at the knee were performed freely, the flexors acting well. After 25 days the patient started to walk though slightly lame. Examination of the electrical excitability gave the following data.

		November 30 C.C.C. A.C.C. milliampers	December 22 C.C.C. A.C.C. milliampers
M.Biceps	15	25 quick contr.	20 30
M.Gastrocnemius	10	15 week from anode	11 11
M.Peroneus	..	.. ..	.. 30 week
M.Flexor gigitorum	no	30 week	no no contract.
M.Semitendinosus	..	.. ..	11 14
Nerve Tibialis	no	no ..	no no
Nerve Peroneus	no	no ..	no no

In walking the patient dragged his foot, but he began to walk satisfactorily. A certain increase of the atrophy of the extremity was noted. Because the reaction of degeneration was found in the muscles of the leg an operation was suggested in order to produce ankylosis of the ankle-joint. In this case it is necessary to note the quite quick restoration of the skin sensation and appearance of functions of the flexors of the leg: biceps, semitendinosus and semimembranosus muscles.

Bobrov and Spijarny's presentation of this case is both instructive and interesting. Spijarny is amazed that after such an extensive excision of the sciatic, flexion of the leg on the thigh should have returned so early. When the leg was straightened after having been held in flexion for 12 days, the patient was able at once to flex the leg upon the thigh, "the flexors acting well." Since the patient's leg was held in flexion from the operation up to this time, the power of flexion in these muscles can not be said to have been absent. In any case as soon as the leg was freed and the opportunity given for them to contract they contracted freely.

From this standpoint the case is extremely instructive. It demonstrates admirably the dual nerve supply to the biceps and semitendinosus and that function is retained in these muscles even when the sciatic is removed *in toto* over an extensive area. Bobrov's comment on the condition of the muscles of the leg displays excellent judgment. He recognizes that the increase in the size of the leg on the affected side is due to infiltration of the tissue, and that connective-tissue changes within the muscles have brought about a lessening of the foot drop and a decrease in mobility within the ankle-joint. He appreciates that such "control" of the foot is due to degenerative changes within the tissues and not to nerve regeneration, as Mackenzie interpreted his case.

Bobrov's conclusion that he had not succeeded in restoring nerve conduction by means of a nerve flap operation is entirely substantiated by his findings.

Before the proceedings of the Society of Psychistry, May, 1895, Bruns presented briefly a case of successful secondary nerve flap operation.

CASE 7. Reported by Bruns (6). A little boy 2 months old was presented in November, 1893, with a neurosarcoma of the right *arm* involving both the median and ulnar nerves. The tumor together with both nerve trunks was excised by Dr. Kredel. Several centimeters (exact extent not given) separated the nerve ends. On account of the malignancy no nerve suture at that time was undertaken.

April, 1895, 5 months after removal of tumor the patient returned, was healthy and had no recurrence. The hand was completely under the control of the musculospiral nerve and held dorsiflexed. The proximal phalanges were extended and the remaining phalanges flexed. Both median and ulnar musculature were completely paralyzed. Complete reaction of degeneration. Analgesia of the palmar surface of the hand.

On April 10, 1894, 5 months after the operation, a secondary nerve suture was made. Both median and ulnar nerve ends were freshened. From the central stump a flap was cut and sutured to the distal (no exact measurements given—"several centimeters").

November 6, 1894, 7 months after the second operation and one year after original operation, Bruns was able to note that the hand no longer was held dorsiflexed. The three last fingers were still in the claw position. The thumb and index finger remained extended. Movements in the ulnar and median musculature were not completely paralyzed. In the flexor musculature of the forearm, no reaction to faradic current; exquisitely slow galvanic reaction.

On the other hand Bruns was able to obtain in the arm above the scar, faradic response in the flexors of the fingers especially in the ulnar area. In January, 1895, 9 months after the flap operation for the first time active movements of the hand appeared. The claw position of the last 3 fingers persisted.

At the present time, May, 1895, the patient is 1 year, 9 months old and is able to move freely the last three fingers; the thumb and index fingers are still somewhat limited. Musculature of the thenar eminence certainly function (opposition and adduction), the ulnar flexors and part of the remaining flexors of the forearm can be stimulated by the faradic current. For the median musculature the outcome is not yet quite determined. The patient uses the hand to eat and to play. It is somewhat smaller than the left hand; otherwise there are no trophic disturbances.

The evidence in this case shows considerable regeneration in the area of the ulnar nerve and less so in the median. It is well known both experimentally and clinically that nerve regeneration is very much more active the younger the individual. Unfortunately the distance separating the nerve ends was not more specifically stated than "several centimeters." It is a well-established fact that nerves, without assistance, may bridge short defects. Notta, Von Langenback, Heuter, Weir-Mitchell and others have reported cases in which such defects were bridged. By some the distance which may be bridged is considered to be about 2 to 3 centimeters. Turning up nerve flaps for so short a distance (several centimeters) may have served in this case to hold the nerve ends in alignment, the nerve flaps in this instance playing a similar rôle to suture a distance with catgut. It would be hard to rule out this possibility as a means of regeneration in this case. And on the other hand it would be equally difficult to attribute the recovery to spontaneous downgrowth of neuraxes, except that we know experimentally, that in the young the neuraxes have tremendous powers of regeneration and that, from experimental evidence, the nerve flap probably does not serve as a conducting path.

CASE 8. Reported by Habermann (20). A young girl, 28 years old, in April, 1893, began to complain of pain in the right foot, mostly over the dorsum and over the toes. The pain became so severe that the patient was hardly able to stand the weight of the bed clothing on the foot. Sitting down caused extreme pain.

Immediately beneath the sciatic notch a freely movable tumor was to be felt. Examination November 7, 1896, showed motor and sensory function of the right leg to be completely normal.

In June, 1893, diagnosis of tumor of the sciatic nerve was made. The patient was handled symptomatically. The pain became more severe and on November 7, 1893, excision of the tumor together with 10 centimeters of the sciatic nerve was performed. The defect was bridged by means of a nerve flap. "Both the nerve and skin wound healed *per primam*."

On the tenth day after the operation a distinct return of sensation was noticed; pain was completely lost. December 25, 1893, patient began to try to walk and in September, 1894, was able to walk freely.

Numerous other tumors appeared over different parts of the body and several operations were performed. In all it was surprising how little impairment of function occurred following nerve excision.

Habermann, in discussing this case, is more concerned with the pathological aspects than with the repair of nerve defects. In the subsequent operations the ultimate outcome of the case was no doubt apparent and no attempt was made to perform nerve suture.

From our standpoint the case is lacking in both pre-operative and postoperative findings to merit further consideration. Individual muscular action is nowhere noted, total movements only being given. On the sensory side no definite forms of sensibility were recorded, nor areas of changed sensation outlined. The case is recorded so that list of nerve flap operations may be more complete.

CASE 9. Reported by Paul Girndt (19). W. A., a medical student, on January 15, 1898, received a saber cut in the right forearm, 10 centimeters below the internal condyle and extending downward 7 centimeters. One and a half hours after injury repair of the severed muscles (not stated which) and the ulnar nerve was done. Infection took place and a necrotic piece of nerve was discharged from the wound. After the wound was healed (time not stated) a secondary suture was performed. The nerve ends were found imbedded in scar tissue and separated by 3 centimeters. A distal flap was turned up to the central end and there sutured. Eight months after the operation the fourth and fifth fingers were still maintained in slight flexion and the hypothenar eminence was atrophic. Sensation over the fifth finger was still impaired. Motility was nearly normal and also reaction to the faradic current, except in the muscles of the hypothenar eminence. The interossei "reacted nearly normal and the same for the flexor carpi ulnaris." The patient is again able to use hand completely. The result is very satisfactory and I doubt not that with further electrical treatment complete cure will take place.

Judging from the site of the injury, 10 centimeters below the elbow, there should have been no paralysis of the flexor carpi ulnaris or the deep flexors to the fourth and fifth fingers. The only impairment of function attributable to the nerve injury would be in the intrinsic muscles of the hand. There is no conclusive evidence given in the report of return of function in these muscles. The hypothenar eminence still shows atrophy and the fifth finger loss of sensation. This report is made less than eight months after the injury and is both incomplete and premature and hence does not admit of any final deductions.

CASE 10. Reported by Debersaques (11). In a man 48 years old a sarcoma was removed together with 12 centimeters of the sciatic nerve. The tumor was about the size of a child's head lying between the biceps and semitendinosus. Both nerve ends were split in half longitudinally and 7 centimeters flaps were made. These were united with three chromic catgut sutures.

Sensory changes occurred on the outer side of the leg and dorsum of the foot. Six days after the operation sensation was normal. A slight pareses remained in the anterior and lateral muscle groups of the leg.

A discussion of this case would be superfluous in view of what has already been said concerning such early return of function and the absence of sufficient data. Furthermore the case remained under observation only one month.

Subbiottch, in reviewing nerve surgery for Serbia, reports a case of nerve flap operation performed by himself. Apparently the case has not been elsewhere reported and the details given are extremely brief; too meager to admit any valuable deduction being drawn. It is quoted in order to make the list of nerve flap operations as complete as possible.

CASE 11. Reported by Subbiottch (41).[1] At operation, 14 days after the accident, I searched in the scar tissue for the deep root of the musculospiral nerve, freshened both stumps and sutured the nerve; the suture had to be preceded by the formation of a small flap in order to elongate the nerve and bring its two extremities in contact; union by first intention was incomplete and the result showed no return of function.

CASES 12 and 13. Reported by Medea and Rossi (29). A brass worker was caught in a fly belt August 26, 1903, sustaining a fracture of the humerus, middle third, and both bones of the forearm, middle third. After union of the fractures a paralysis of the radial nerve was discovered and progressive atrophy of the forearm and hand.

On May 13, 1904, examination showed excessive callus at the junction of the middle and upper third of the humerus; callus and some deformity at junction of the middle third and the superior third of the radius and ulna which limits enormously supination and pronation; paralysis and atrophy in the radial area with the exception of the triceps and supinator longus muscle; some anæsthesia in the middle of the posterior surface of the forearm corresponding to lower internal cutaneous nerve.

Electrical examination showed complete reaction of degeneration in the musculospiral nerve in forearm; a slight quantitative diminution of the other muscles, especially the interossei.

Operation, May 5, 1904, 8 months after injury. Incision made four fingers' breadth above the elbow over the course of the musculospiral up to the junction of the middle and superior thirds of the humerus. The radial nerve was

[1] *L'etat actuel de la chirurgie nerveuse*, 1903, ii, 576.

imbedded in scar and callus and in places reduced to a single connective tissue band one-third the diameter of the normal nerve. Resection was made and 8 centimeters removed. Flaps were made about half the diameter of the nerve from both stumps and united with 3 sutures. A new muscle bed was prepared and the wound closed in the usual manner. Healed *per primam*. Functional result was not yet established at the end of a year. Sensation is a little better. Some improvement in the electrical examination.

In commenting upon this case Medea and Rossi believe that a better result had not been obtained due to the fact that the nerve flap operation was undertaken 8 months after the injury and that because of the formation of flaps and the distance bridged a greater time would be required than if direct suture had been done. Their conclusions would seem to be warranted.

No doubt the report is made too early and that no evidence for or against the nerve flap operation can be deducted.

Medea and Rossi state that sensibility is a little better and that a little improvement is to be noted in the electrical examination. From a critical standpoint such remarks unfortunately indicate very little. The question naturally arises, What form of sensation has shown improvement and to what extent have the borders of anæsthesia contracted? Such evidence if given would afford some index of regeneration. As reported at this time the case must be classified as premature and unfortunately no evidence can be deducted in support of nerve flap operation.

CASE 14. p. 170. Nineteen year old boy, gas worker, on January 24, received a cut in left popliteal region. Profuse hæmorrhage occurred. The wound was considered superficial and was closed with two silk sutures.

Two days after he reported to the Ospedale Maggiore. Examination showed wound to be 1 centimeter *below* the articular line of the knee-joint; transverse and with the internal extremity 1 centimeter from the middle line and continuing toward the external boundary of the popliteal space.

There is an intense tumefaction which causes a bulging of the entire space. It is elastic and pseudofluctuating. The leg is swollen and tense. The patient has a feeling of great tension in the articulation and can not move his foot. A few days later the symptoms increased and in spite of a clean wound the tumefaction is greater. Cyanosis has become marked and has extended up the whole leg to the lower third of the thigh. The patient holds the leg slightly flexed; movements in the knee-joint are limited—flexion to 90°.

Plantar flexion of the foot and toes is not possible on account of paralysis of the left internal popliteal. Movements in the region of the external popliteal are present.

Examination of sensation shows a zone of anæsthesia on the foot corresponding to the external margin and occupying the middle one-third of this. There is also another zone of anæsthesia to pain corresponding to the internal border of the foot and the first phalanx of the big toe. On the sole of the foot in the median and posterior portions there is hyperæsthesia, more marked on the plantar surface of the toes and also slight hyperæsthesia on external posterior aspect of the leg. Trophic changes are present on the plantar surface and over the heel.

Electrical examination shows reaction of degeneration in the area of the internal popliteal. Achilles reflex has disappeared.

Diagnosis of aneurism and lesion of the internal popliteal nerve made. Because of intense pain, on request of the patient, operation was done February 10, 1904, 17 days after injury and aneurismal sack was found. The internal popliteal nerve was exposed in the upper part of the popliteal space and followed down. It was found severed, 4 centimeters separating the ends; proximal and distal ligation of the popliteal artery was made. A flap 4 centimeters long consisting of half the diameter of the internal popliteal nerve—the external half being taken—was made.

On account of the arterial complication is was deemed best not to try to flex the knee in order to bring the segments together. Wound healed *per primam*.

On the 17th (month not mentioned, presumably March) the patient complains of some pain on the sole of the foot; on the 25th some improvement in motility was noticed. Plantar flexion of the foot at first was almost impossible but began to be complete although weak. The improvement in motility proceeded rapidly, whereas the examination of sensibility showed no marked improvement up to June 5. From that date on sensibility began to be normal. Fifteen months after the last operation May 25, 1905, the date of the last examination, we recognized an improvement in motility almost sufficient to call it a cure. There remained still difficulty in plantar flexion of the toes. Achilles reflex was weak. Sensation has become perfectly normal. Electrical examination of the gastrocnemius does not contract with the faradic and gives almost no response to the galvanic current. Stimulation of the tibialis posticus gives only a weak contraction.

There are certain points of extreme interest in this case, particularly the very quick recovery of plantar flexion occurring about 35 days after the operation—a period too short to permit of nerve regeneration and the reformation of the motor end plates. It must be recalled that the level of the knife wound was 1 centimeter below the joint line. The muscular branches to the inner and outer heads of gastrocnemius come off from the internal popliteal nerve a little below the apex of the popliteal space—higher than the level of the incised wound.

In order to determine this point two experiments were made on the cadaver. The internal popliteal was severed 1 centimeter below the line of the knee-joint—this level being determined by inserting a knife within the joint cavity and by marking the skin by means of a skin pencil. The popliteal space and upper one-third of the leg were dissected. The two nerves to the heads of the gastrocnemius were found high up in the popliteal space, about 5 centimeters above the point at which the internal popliteal had been severed. These branches immediately diverge from the nerve trunk to enter the substance of the gastrocnemius and at once begin to send off short filaments to the muscle. At the level at which the internal popliteal was severed these two nerves lie approximately 3 centimeters lateral and mesial to the nerve trunk. These nerves might then probably have escaped injury and thus the early motility in these muscles might be accounted for.

Due to the intense tumefaction and excessive pain

these muscles no doubt were held in a fixed position established by the pain reflex. Hence, the Achilles jerk might not have been obtained though present. The above anatomical findings might be suggested to account for the almost immediate return of plantar flexion of the foot. However, against this, Medea and Rossi state reaction of degeneration was present. This examination was made a few days after the injury. We know that the reaction of degeneration does not occur generally until some little time has elapsed after nerve severance—rarely under two weeks and more often three weeks. In the presence of extensive œdema, as here described, both sensory and electrical examination can not be done with accuracy; even slight œdema would interfere with the passage of the current.

However, there would seem to be one point of evidence which has been constant throughout. There could be no question of the severance of the nerve supply at the time of injury to the flexors of the toes. At no time following the nerve flap operation has there been any return of power in these muscles.

It is regrettable that more details are not given in this unusual case. One can not help seeing the necessity for greater uniformity, accuracy, and detail in the published reports of nerve injuries.

CASES 15 and 16. Reported by Goldmann (16). A woman 48 years old, noticed for the last six years a tumor at the level of the right elbow. During the last two years she complained of pain which prevented her from working. Pressure over the tumor called forth marked pain referred to the fifth finger. There was no motor or sensory paralysis.

On February 7, 1905, a tumor of the ulnar nerve was removed together with 5 centimeters of the nerve trunk. The defect was bridged by means of central and peripheral nerve flaps. Healing *per primam*.

After the operation there was no disturbance in the motility of the hand and fingers. Sensation was lost over the fifth finger.

Ulnar flexion of the right hand was undisturbed; contraction of the flexor carpi ulnaris was distinctly felt. No difference between the right and left hands. Spreading and closing of the fingers, also extension of the distal two phalanges was possible. The thumb adducted equally on both the right and left. The opponens and flexor digiti minimi contracted. No muscular atrophy.

At the ulnar point above the wrist the ulnar nerve can be stimulated by the faradic current. All ulnar muscles respond to galvanic and faradic currents. No reaction of degeneration.

Hypæsthesia over the whole of the fifth finger and hypothenar eminence. The remaining ulnar area shows no loss of sensation. Trophic changes appeared over the fifth finger.

May 19, 1916, 15 months after operation, there was still no atrophy of the muscles of the hand or of the flexor carpi ulnaris. No distinct flattening of the hypothenar eminence or depression of the interspaces. The adductor pollicis was distinctly palpable.

Electrical examination in the arm and upper two thirds of the forearm gave no response to either the faradic or galvanic. At the ulnar point above the wrist distinct contraction of the ulnar musculature could be obtained. Sensibility is impaired over the fifth finger and along the fifth metacarpal, also slightly on the ulnar side of the fourth finger. Temperature sense is less disturbed than pain and touch.

After removal of 5 centimeters of the ulnar nerve above the elbow, no motor paralysis appeared and only some impairment of sensation over the fifth finger and hypothenar eminence. There was no disturbance of the motility of the individual ulnar musculature. Had not more detailed evidence been given this case might have been included among those of immediate return, or in the category of supplementary movements. Electrical examination above the site of the nerve flap operation gave no response in the ulnar distribution, which precludes the possibility of such interpretation. The fact that stimulation of the ulnar nerve at the wrist gave full response in the ulnar domain of the hand would seem to point to the presence of an abnormal communicating branch, probably between the ulnar and median as referred to by Halipré.

The only clear manifestation of nerve section was the loss of sensation of the ulnar area of the hand. This persisted throughout and "in spite of re-establishment of continuity of the nerve trunk by means of nerve flap . . . 18 months after operation . . . the sensory impairment has remained unchanged as the only evidence of nerve resection." Thus following the nerve flap operation and "re-establishment of nerve continuity" no improvement had taken place.

CASE No. 2. The patient presented herself on July 3, 1904, complaining of pain referred to the fifth finger and a swelling in the right forearm five centimeters above the wrist. Diagnosis of neuroma of the ulnar nerve was made. Motility of the finger and hand was normal.

Operation with removal of 5 centimeters of the ulnar nerve. Defect was bridged by both central and peripheral flaps. An examination made almost immediately after coincides with the examination made June 3, 1906, two years after the operation. The fifth finger is held in abduction, the remaining, while at rest, are held slightly flexed. This position can be corrected at will without much effort. It is impossible to flex the second and fifth fingers at the metacarpophalangeal joints with simultaneous extension at the interphalangeal joints. With each attempt to perform this movement the distal phalanx is flexed. The patient readily performs the correct movement with the other hand. Adduction and abduction of the second to fifth fingers is possible with the exception of adduction of the fifth against the fourth. Both the force and amplitude of these movements are markedly diminished. Adduction of the thumb is present but is more or less diminished. Flexion of the fifth finger is markedly diminished, opposition somewhat better, and radial adduction not at all possible.

There is marked flattening of the hypothenar eminence, slight depression at the site of the adductor pollicis, and distinct atrophy over the interossei.

Electrical examination. By stimulation of the ulnar in the arm only contraction of the flexor carpi ulnaris was obtained. A distinct response of the muscles of the hypothenar eminence and the lumbricales by stimulation in the arm could not be demonstrated. In the forearm the adductor pollicis and the abductor of the fourth finger can be readily stimulated.

Galvanic gave no reversal of the normal reaction; no increase in either mechanical or electrical irritability.

Sensation. On the ulnar side of the fifth finger tactile and temperature sense are wanting. Pin prick over the entire area as well as over the tip of the fifth finger is quantitatively diminished.

In commenting on this case Goldmann states that following the operation there occurred merely a diminished action in the ulnar musculature, which in the course of two years has not improved in spite of re-establishment of nerve continuity by means of nerve flaps. This conclusion is amply supported by both the motor and sensory findings, as well as by the presence of atrophy over the hypothenar eminence, the interosseii and the adductor pollicis. The description given of the attempts of the patient to extend the distal two phalanges of the second to fifth fingers is very characteristic of paralysis of the ulnar nerve. Extension of these two phalanges is a function of the interosseii. In this case that function was totally wanting at the end of two years. Goldmann describes a limited degree of separation of the fingers. This as stated before in an ulnar paralysis may be accomplished by the extensor muscles.

There are certain unusual features in the electrical reactions which Goldmann has used as evidence in support of absence of loss of function following resection of a peripheral nerve. The discussion of this theory would hardly come within the scope of this paper.

However, several interesting points are raised in these three cases because of the remarkable fact that following the removal of 5 centimeters of the ulnar nerve no paralysis or only slight paralysis occurred. This finding seems not to be rare following removal of slowly growing tumors from peripheral nerves, especially the ulnar. Extensive formation of communicating branches according to Schede and Goldmann are formed in the same manner as the collateral circulation is established after ligation of a blood-vessel. However, while such formation is the rule in the vascular system it is the exception in the nervous system.

A further possible explanation may be found by the not infrequent communicating branch between the median and ulnar nerves present in about one in five cases according to some anatomists. Considerable variability seems to exist in the peripheral distribution of both the median and ulnar nerves; the median taking over part of the ulnar distribution in the hand and *vice versa*. Halipré has recently cited such a case. The ulnar nerve was completely severed above the elbow with complete loss of sensation over the fourth and fifth fingers but with no atrophy of the small muscles of the hand and very slight in the forearm. At operation stimulation of both ends gave no response but when stimulated lower down contraction occurred in the peripheral distribution of the ulnar. It would not seem improbable that perhaps these other cases of Auerback and Brodnitz, and Goldmann might be accounted for in the same manner.

CASE 17. Reported by Auerback and Brodnitz (1) Nineteen-year-old baker's helper presented himself on January 4, 1908, complaining of pain in the inner side of the forearm and left hand. The fourth and fifth fingers felt cold and in them sensation was also impaired.

Diagnosis of neurofibroma of the ulnar nerve, one year's duration was made. Examination three months previously in another clinic showed the fifth finger to have been somewhat cyanotic and the skin smooth and shiny.

The present examination revealed hypæsthesia on the ulnar side of the hand and lower third of the forearm. anæsthesia of the whole of the fifth finger and the ulnar side of the fourth.

Marked atrophy of the third and fourth interosseii spaces, the adductor pollicis and the hypothenar eminence. The function of these muscles was distinctly lessened. Electrical reaction of the third and fourth interosseus space showed polar equality, anodal closure-contraction equaled kathodicc losure-contraction. On the nerve trunk above the tumor only strong faradic and galvanic currents gave any contraction in the flexor carpi ulnaris and no reaction in the adductor pollicis or the interosseii. However, the interosseii reacted with strong currents at the ulnar point at the wrist.

Because of the increasing pain and rapid growth of the tumor, excision was performed January 21, 1908, and 5 centimeters of the ulnar *in toto*, was removed. The nerve defect was bridged by both central and peripheral flaps. Healing *per primam*.

The patient was under observation for four and a half months after operation. Five weeks after operation he returned to the work which, on account of pain, he formerly was unable to do. The last examination was made in the middle of June, 1908. At this time there was only a minimum deficiency in ability to appreciate tactile sensation on the palmar side of the distal phalanx of the left fifth finger and also a similar area over the third and fourth interosseus spaces. Partial reaction of degeneration was no longer present. The strength of the hand had returned to normal. In spite of the large defect "it was astonishing that from the earliest moment after interference (removal of 5 centimeters) absolutely no kind of impairment of motility ensued."

It is rather difficult to attempt to discuss this case from the viewpoint of bridging nerve defect by means of nerve flap. In the first place observation extended only over a period of four and a half months, obviously a time too short to admit of any definite conclusions. However, no evidence is cited in this case which warrants the conclusion that, as a result of the nerve flap operation, restoration of function occurred. From a negative standpoint it is of value and is therefore recorded.

Because of the marked similarity in retention of ulnar function following excision a more general discussion of this case is included in the remarks concerning the two reports of Goldmann.

CASE 18. Reported by Hashimoto and Tokuoka (22). Soldier, gunshot wound October 14, 1904, sciatic paralysis. Entrance right leg above and behind the internal epicondyle; exit behind and above the external condyle. There was considerable hæmorrhage, the patient was unable to walk, and seven days after injury he began to have pain referred to the tip of the foot. Paræsthesia of the lower leg; anæsthesia dolorosa of the foot; foot drop. Distinct trophic changes and a trophic ulcer in the region of the right external malleolus.

Operation, January 16, 1905, 92 days after injury. The tibialis nerve was thickened and spindle shaped, the peroneus severed, and both nerves were imbedded in scar tissue. Six centimeters separated the ends of the peroneus nerve. Ascending and descending neuritis in both nerve trunks. Neurolysis was performed on the tibialis nerve. Flaps were made from the peroneus nerve. Eleven months after the operation the patient was able to dorsiflex his foot 95 degrees. Paræsthesia still present on the dorsum and sole of the foot. Result good.

There seems to be little question of improvement so far as one may judge from the report. Unfortunately individual muscular action has not been given. Such incredible rapidity, in the presence of a secondary suture, with which the neuraxes have bridged a defect 6 centimeters has not been substantiated by the reports of nerve injuries in this war. It should be remembered that in order to have voluntary motion, as exists in this case, the neuraxes must bridge the defect, not only, but continue their growth through the distal segment and penetrate to the individual muscle fibers to reform the motor end plates. It would be of interest had the authors given more information concerning the method of preparing the nerve flaps. By cutting the central flap so that it is almost severed from the nerve trunk, yet still connected by a small amount of tissue, it is conceivable that the neuraxes might readily penetrate; whereas such would probably not be the case if the flap were cut to within 1 centimeter or thereabouts of the nerve end. In the former instance the nerve flap would essentially be an autogenous nerve transplant with the disadvantage, however, of having a poor line of union with the severed neuraxes and having been taken from the nerve trunk from which regeneration must take place thus damaging and diminishing its power of regeneration.

Case 19. Reported by Berdjajew (7). A soldier 27 years old, on September 7, 1909, entered the Odessa Military Hospital, four months previously having received a stab wound in the left arm 5 centimeters above the joint line of the elbow. The wound had been infected. There was some scar tissue and the scar was adherent to the underlying muscles. Pressure over the wound caused local pain. The fingers were held flexed at the metocarpophalangeal joints and half flexed at the interphalangeal joints. The thumb was flexed and adducted. There was wrist drop. Active extension of the wrist and fingers, as well as supination of the wrist were impossible. Adduction and abduction was limited. Electrical examination gave no response below the level of the lesion.

Sensation was lost over the dorsum of the wrist and hand with the exception of the fifth finger. Both pain and cold stimuli were not appreciated. Operation, October 10, 1909. After freshening both nerve ends they were *brought together* with two through-and-through and four superficial sutures.

On the following day Berdjajew reports that extension of all the fingers was possible. On the eighth day when the dressings were removed the patient was able to supinate and also extend the fingers at the metocarpophalangeal joints. Extension at the wrist had not been restored. Pain and temperature sense had returned and the patient was able to distinguish between hot and cold.

A second operation was performed February 4, 1910, because there was still slight paralysis. At *this time* there was anatomical continuity except for a small part on the periphery. A slender flap 1 centimeter long and 2 to 3 millimeters wide was taken from the central part and continuity established with the peripheral end.

Following this procedure the movements of the fingers remained unimproved. The patient was observed for one month and was not again seen.

A nerve flap operation was not really performed in this case. At the first operation the ends were brought in anatomical continuity and in the second this was not interrupted. At this time a slight repair was made of a small lateral defect by means of a central piece 2 to 3 millimeters wide. For this reason the case does not really concern this report. It is mentioned in order that it may not again be referred to as a nerve flap operation. Coste and Gerulanos both have quoted Berdjajew's case as a nerve flap operation. The summary given by Coste and also in the *Zentralblatt fuer Chirurgie*, 1910, p. 1573, is misleading and inaccurate. Quite a few inaccuracies have been found in reviewing these cases due to writers not searching the original articles.

Gerulanos in treating the Greek wounded in the Balkan War performed a nerve flap operation on 4 cases. In one, a brachial plexus injury, nerve flaps were made on 3 cords, in two of the remaining cases, both the median and ulnar nerves, and in the fourth case the ulnar nerve alone. In three of these cases no postoperative report was made, the patients apparently having been lost sight of. The remaining case was observed for 4½ months following operation.

For this reason unfortunately no data of any value can be deducted from these four cases on which eight separate nerve flap operations were performed.

Gerulanos was convinced of the value of the nerve flap operation especially by the report of Mackenzie's case which he quotes as having been successful. Gerulanos' view has been shared perhaps by many and indicates the rather imperative need for a critical study of Mackenzie's and other reports.

Cases 20 to 23. Reported by Gerulanos (13). Gunshot wound December 5, 1912; entrance above the middle of the right clavicle; exit posteriorly in the suprascapular region. Paralysis of the shoulder muscles and the whole arm. Sensation lost over the entire arm. Atrophy of all the arm musculature. The paralysis is complete in the region of the shoulder. Arm and forearm musculature show severe reaction of degeneration with *exception of the flexors of the hand and fingers*. Complete loss of excitability of the musculospiral and marked impairment in the *ulnar* and *median nerves*.

Operation on May 20, 1913, 165 days after injury. Considerable scar tissue in the region was found. The nerve ends were freed.

The fifth cervical cord over an area of 5 centimeters was surrounded with scar; 2½ centimeters of this was shattered and resection was done (length removed not given). A nerve flap was turned up from peripheral end.

The sixth cervical cord showed marked scar tissue changes. A 3-centimeter segment was removed and nerve flap made from the central stump.

The seventh cord was imbedded in callus of the transverse process of the vertebra and imbedded in it was a small bone splinter; resection of 3 centimeters and repair by means of flaps from both stumps. Both the eighth cervical and first thoracic were likewise imbedded in callus but were freed, no resection was made and these nerve trunks were surrounded by fatty tissue from the region.

Examination 4½ months after operation November 5, 1913, showed distinct improvement in the area of musculocutaneous and ulnar, less in the distribution of the median and musculospiral. Increase in the reaction of degeneration of the deltoid, supraspinatus and infraspinatus.

It is interesting to note that in the eighth cervical and first thoracic roots, though imbedded in callus, were not excised but freed. Apparently so far as one may judge, improvement was found in the distribution of these cords alone.

Gerulanos speaks of improvement in the area of the ulnar nerve and of examinations made in the distribution of the remaining nerves, as if by such examination some index of the status of the injury might be elicited. It is obvious that one can not discuss in this case return of function or loss of function in terms of peripheral nerve trunk distribution. The injury here was to the nerve cords and a radicular examination should have been made. Not only does this apply to the individual muscular action but also to the sensory distribution. On the upper (fifth and sixth cervicals) and the middle (seventh cervical) nerve flap operations were performed. In the peripheral distribution of these, so far as one may attempt to judge from the report, practically no change took place. Whereas, on the other hand in the lower group (eighth cervical and first thoracic) where resection was not done but the cords were freed improvement had occurred in their distribution at the end of 4½ months. It is well known that following neurolysis most rapid return of function may take place and in this case when both methods were employed in the same wound some idea of the relative difference might be suggested.

CASE 3, p. 251. Gunshot wound of the right axilla, entrance at the anterior border through the chest; exit posteriorly near the ninth thoracic vertebra.

Paralysis of the right arm, extension of the forearm, pronation and supination. Complete movements of the hand and fingers impossible. Marked anæsthesia, especially in the ulnar area.

Electrical examination showed complete paralysis of the musculospiral median and ulnar.

Operation February 22, 1913, 126 days after injury. The musculospiral, ulnar and median nerves were imbedded in scar and an aneurism was found. Resection of 5 centimeters of the ulnar. Nerve flaps were made from both ends. The wound healed *per primam*.

No further examination following the operation was made of this case.

CASE 5, p. 252. Gunshot wound July 14, 1913, of right arm below the axilla. Wound infected. Some necrosis of the skin and forearm. Complete paralysis of all movements of the forearm and musculature of the hand. Pronation and supination possible, though distinctly impaired. Paralysis of the musculospiral, median, ulnar and internal cutaneous. Arterial pulse absent.

Operation November 9, 1913, 87 days after injury. Scar tissue found in the axilla. Vessels and nerves completely severed, the ends being 5 centimeters apart; the musculospiral nerve ends were held together by scar tissue. Musculospiral nerve sutured. Nerve flap operation on the ulnar using a central flap 5 centimeters long. A large defect of 7 centimeters in the median. Both stumps were implanted into the ulnar.

No further report of this patient was made.

CASE 11, p. 252. Gunshot wound February 19, 1913, in the left axillary space; exit posteriorly through the scapula, passing through the chest. Paralysis of all the arm muscles with œdema, cyanosis, and atrophy. Electrical examination showed complete paralysis of all muscles of the arm. Complete reaction of degeneration.

Operation December 5, 1913, 290 days after injury. From within the axilla to the arm over a distance of 10 centimeters only scar tissue and no nerves or vessels to be found. From above and below each trunk was found and followed. The ends were imbedded in scar and callus. Only the musculocutaneous was found as such. In all others continuity was lost. Defect of 6 to 8 centimeters bridged by means of nerve flaps. A muscle flap from the latissimus dorsi was brought into the wound and surrounded the nerves. Healed *per primam*.

No further report is given of this case. The formation in this operation of a muscle flap around the repaired nerves should be condemned as stated earlier in reference to Mackenzie's case in which he pulled the nerve flaps through a muscle tunnel. The presence of bleeding and torn muscle fibers does not serve to prevent adhesions and scar tissue formation about the nerve, but rather tends to *increase* their production. When in the presence of extensive scar, as found in this case, the desire to create a more favorable environment can hardly be suppressed by the surgeon. However, it is better to recognize that certain procedures while appearing at the time of operation to improve conditions in the end make them worse.

SUMMARY

Thus both the experimental and clinical evidence has been reviewed to determine the value or futility of the nerve flap operation in bridging nerve defects.

Judging from the reports, the clinical evidence shows only one case (7) in which, as a result of nerve flap operation, there was distinct return of function, and one case (18) in which there was some improvement. Hashimoto's report unfortunately is incomplete and does not admit of a proper critical survey. In the other, Case 7, in which there was a definite return the gap bridged was less than the distance Notta, Heuter, Langen-

beck, Horsley, and others have shown may be overcome without surgical assistance. Nevertheless, it can not be said in this case that the neuraxes grew into the distal segment without passing through the nerve flaps. On the other hand it can not be claimed that such downgrowth did take place through them.

Perhaps this answer may be found in a study of those cases in which the distance to be bridged was greater than may generally be overcome by spontaneous downgrowth. In *no* such case was there *convincing* evidence that as a result of the nerve flap operation any real improvement was established. A "return," frequently within a few days or weeks, has been reported in muscles which were *assumed*, judging from the site of the lesion, to have been paralyzed. Such early return has been shown, even for primary suture, in which there is essentially no distance to be bridged by the neuraxes, to be incorrect and to be based on either incomplete examination or fallacious deductions. Thus the very date with which return of function is attributed, were there no other evidence, would in itself suggest that the nerves to these muscles had not been severed and that in them no paralysis had existed, viz., Cases 12 and 19.

A distinction must be made between the level of the lesion of the nerve trunk and the level at which nerve branches leave the trunk. There branches may follow a separate course and supply, at a higher level than the injury, muscles whose action is below the point of severance of the nerve trunk and whose nerve supply is presumed, therefore, to have been severed. For example the nerve to the hamstrings to all purpose is not a branch of the sciatic. It is a separate and distinct nerve, in close proximity to the sciatic, supplying the hamstrings, both by an upper and lower set of branches. The upper set is rarely severed. Thus through the semitendinosus, some flexion of the leg on the thigh may be accomplished. The nerves to the gastrocnemius and soleus come off the internal popliteal well above these muscles and pursue a separate course, supplying them with both an upper and lower set of branches. Other examples might be given; these suffice to emphasize the point that muscles can not be *assumed* paralyzed because of the level of the injury to the nerve trunk, but must in each instance be demonstrated paralyzed. Neglect of this point has led to the erroneous conclusion that return of function has taken place and therefore, reported successful.

Another even more common cause of error has been the acceptance of the performance of a total movement of the part as valid evidence of return of function. To be able to walk or write or otherwise move the hand or extremity does not affirm that nerve regeneration and restitution of conductivity has taken place. As has been pointed out, many such movements may be accomplished by other muscles without the paralyzed muscles playing any rôle—*motilité supplée of Létiévant. Individual muscular action* must be given both before operation, as evidence of paralysis, and after operation as proof of return of function. Mackenzie's case in particular does not offer in either paper conclusive evidence to substantiate his statement that there has been "progressive regeneration . . . on a colossal scale." As reported the motor, sensory and trophic evidence tends to show that effective regeneration has *not* taken place.

Other errors of interpretation have occurred and have been responsible for failures, so far as the nerve flap operation was concerned, being classed as successful. The most striking example is Tillmann's case, so long accepted as successful. It has been, in a measure, responsible for a continuation of this method of nerve suture. Had the case been studied more thoroughly it might have been shown that the essential improvement was not due to the nerve flap operation, but to the liberation of tendons, bound down into a "tendinous knot."

More often the observation of these cases, prior to reporting them, has been over a period too short to admit of any final conclusions.

Judged purely from a clinical standpoint there is insufficient and inadequate data to warrant a continuation of the nerve flap method in the surgical repair of nerve defects.

On the experimental side no evidence has

been found in its favor. In none of the experiments were any regenerating neuraxes demonstrated within the nerve flap or the peripheral nerve segment.

The end sought by the formation of nerve flaps in bridging defects is to afford conducting paths to the downgrowing neuraxes. By the very mechanical arrangements of the flaps this end is practically annuled. The downgrowing neuraxes find little or no opportunity to enter the paths thus offered. In addition considerable damage is done the nerve either by removal of a portion of the trunk from which regeneration is to take place or by removal of branches to the muscles.

Thus from a study of clinical, experimental, and anatomical data, the futility of bridging nerve defects by means of nerve flaps would seem to be definitely determined.

It is a particular pleasure to express my gratefulness to Dr. Huber, Director of the Anatomical Department, in whose laboratory it has been my good fortune to work, for reading the manuscript and the valuable suggestions and criticism he has kindly offered.

CONCLUSIONS

1. The repair of nerve defects by means of nerve flaps has not been definitely supported clinically, as evidenced by a critical study of the reported cases.

2. Experimentally it has been shown that nerve flaps do not serve as conducting paths for the downgrowing neuraxes.

3. Nerve flaps whether central or peripheral are merely degenerated partial nerve segments. Continuity and union of neuraxes does not take place at point of suture.

4. To avoid fallacious deductions it is important to distinguish between the level of the injury to the nerve trunk and the level at which muscular branches arise.

5. Abnormal communicating branches are not rare, particularly between the median and ulnar. Such anomalies must be taken into consideration in any careful study of nerve injuries.

6. Judging from the level of the lesion, muscles may not be presumed paralyzed but should be demonstrated paralyzed.

7. Total movements may *not* be offered as evidence of return of function. The action of *individual* muscles must be given.

8. Reports of peripheral nerve injuries, to be of value, must be accompanied by motor, sensory and electrical findings.

9. By the formation of nerve flaps from the central stump a portion of the nerve from which neuraxes must grow is removed. Distal as well as central flaps may sever muscular branches. By reversing the flaps they are taken out of their field. Thus the downgrowing neuraxes are prevented from reaching the muscles through these muscular branches, even were regeneration to take place.

10. The nerve flap method to bridge nerve defects should be *discarded* in peripheral nerve surgery.

BIBLIOGRAPHY

1. Auerback and Brodnitz. Neurologisch-chirurgische Beitraege. Mitt. a. d. Grenzgeb. d. Med. u. Chir., 1909–10, xxi, 573.
2. Auerback. Ueber die heutigen Leistungen und die naechsten Aufgaben der operativen Neurologie. Beitr. z. klin. Chir., 1911, lxxiv, 82.
3. Bardenheuer. Mitteilungen aus dem Gebiete der Nervenchirurgie mit einer einleitenden Abhandlung ueber die anatomische Verheilung der Nervenverletzungen. Deutsche Ztschr. f. Chir., 1908, xcvi, 24.
4. Bobrov. The removal of sciatic nerve over an extent of 12 centimeters. Khirurgicheskaya Lietopis, Moscow, 1895, v, 578.
5. Brenner. Nervenplastik, 10 Jahre nach der Verletzung (Heilung). Wien. klin. Wchnschr., 1891, iv, 337.
6. Bruns. Verhandlungen psychiatrischer Vereine. Allg. Ztschr. f. Psychiat., lii, 656.
7. Berdjajew. Concerning the question of nerve suture. Vienna-Med. J., 1910, ccxxix, 6.
8. Chipault. L'etat actuel de la chirurgie nerveuse. 1901–1902–1903, vols. i, ii, iii.
9. Claude, Dumas, and Porak. Adaptation fonctionnelle par suppléance dans les paralysies traumiatiques des nerfs. Presse méd., 1915, June 10, 205.
10. Coste. Nervennaht, Nervenanastomosen and Neurolyse. Ztschr. f. d. ges. Neurol. u. Psychiat., 1913, vi, 721.
11. Debersaques. Sarcome englobant le nerf sciatique resection étendue du nerf neurorrhaphie guérison. J. de chir. et ann. Soc. belge de chir., 1902, No. 4.
12. Dittel. Lappenfoermige Autoplastik am Nervus ulnaris. Wien. klin. Wchnschr., 1891, iv, 335.
13. Gerulanos. Schussverletzungen der peripheren Nerven aus den Balkankriegen. Beitr. z. klin. Chir., 1914, xci, 222.
14. Gleiss. Beitraege zur Nervennaht. Beitr. z. klin. Chir., 1893, x, 387, Case 8.
15. Goldmann. Beitrag zu der Lehre von den Neuromen. Beitr. z. klin. Chir., x, 13.
16. Goldmann. Ueber das Fehlen von Funktionsstoerungen nach der Resektion von peripheren Nerven. Beitr. z. klin. Chir., 1906, xli, 183.

17. GOSSET. André-Thomas and Lévy-Valensi. Deux cas de greffe nerveuse chez l'homme avec retour partiel de la motilité et de la sensibilité. Compt. rend. Soc. de biol., 1918, July 6, 693.
18. GRATZL. Schussverletzungen peripherer Nerven. Beitr. z. klin. Chir., 1915, xcvii, 291.
19. GIRNDT. Ueber Resultate der Nervennaht mit besonderer Berucksichtigung der Nervenplastik. Inaugural Dissertation, Berlin, 1899.
20. HABERMANN. Beitr. z. Kenntniss der secundaer malignen Neurome. Muenchen. med. Wchnschr., 1898, xlv, 713.
21. HALIPRÉ. M. A. Société de Neurologie de Paris. Rev. neurol., 1917, Nos. 10–11–12, 236.
22. HASHIMOTO and TOKUOKA. Ueber die Schussverletzungen peripherer Nerven und ihre Behandlung (Tubulisation). Arch. f. klin. Chir., lxxxiv, 354.
23. HEINMANN. On gunshot wounds of peripheral nerves. In addition anatomical investigation on the internal structure of large nerve trunks. Arch. f. klin. Chir., 1916, cviii, 107.
24. HUBER. A study of the operative treatment in loss of nerve substance in peripheral nerves. J. Morphol., 1895, ii, No. 3.
25. KRAMER. Zur Neurolyse und Nervennaht. Beitr. z. klin. Chir., xxviii, 423.
26. LANGLEY and HASHIMOTO. On the suture of separate nerve bundles in a nerve trunk and on internal nerve plexus. J. Physiol., 1917, li, 318.
27. LÉTIÉVANT. Traité des sections nerveuses. Paris: Bailliers et Fils, 1873, Case 14, p. 415.
28. MACKENZIE. Resection of the sciatic nerve. Ann. of Surg., 1909, l, 295.
29. MEDEA and ROSSI. Lesioni traumatiche dei nervi periferici. Clin. Chir., 1906, xiv, 69.
30. NAGEOTTE. Étude experimentale de la cicatrisation des nerfs. Lyon chir., 1918, xv, 16.
31. NEUGEBAUER. Zur Neurorrhaphie und Neurolysis. Beitr. z. klin. Chir., xv, 465.
32. NOTTA. Sur un cas de régénération des nerfs du bras á la suite de leur destruction dans une étendu de 5 centimètres. Arch. gén. de méd., 1872.
33. PIERSOL. Human Anatomy. Lippincott & Co., p. 1333.
34. POWERS. The bridging of nerve defects. Ann. Surg., 1904, xl, 632.
35. v. SAAR. Ztschr. f. orthopaedische Chirurgie. Beitr. z. Nervenplastik., 1913, xxxii, 460.
36. SCHEDE. Chirurgie der peripheren Nerven. Penzoldt-Stintzing; cited in Goldmann. 1906, li, 193.
37. SHERREN. Some points in the surgery of the peripheral nerves. Edinb. M. J., 1906, lxii, 297.
38. SHERREN. The distribution and recovery of peripheral nerves studied from instances of division in man. Lancet, 1906, p. 809 and 886.
39. SPIJARNY. Concerning nerve suture. Khirugicheskaya Lietopio, 1894, xiv, 143.
40. SPITZY. Technique of neuroplasty. Am. J. Orthop. Surg., 1904, Aug., p. 9.
41. SUBBIOTTCH. L'etat actuel de la chirurgie nerveuse. Chipault, 1903, vol. 2, p. 576.
42. TILLMANNS. Ueber die operative Behandlung von Substanzverlusten an peripheren Nerven. Arch. f. klin. Chir., 1885, xxxii, 923.
43. WOLBERG. Kritische und experimentelle Untersuchungen ueber die Nervennaht und Nervenregeneration. Deutsche Ztschr. f. Chir., xviii, 293; xix, 82.

DEPARTMENT OF TECHNIQUE

METHODS OF CLOSING FÆCAL FISTULÆ

By P. LOCKHART-MUMMERY, F.R.C.S. (Eng.), London, England
Senior Surgeon, St. Mark's Hospital for Diseases of the Rectum, London; Senior Surgeon, The Queen's Hospital for Children, London; Consulting Surgeon for Diseases of the Bowel, City of London and Fulham Military Hospitals

THE war has maimed our manhood in many dreadful ways, but there are few more distressing cases than those of men left with fæcal fistulæ. They are unpleasant to themselves and their friends, life is only tolerable with the constant attendance of a skilled nurse, and many of them would sooner die than be condemned to live on in such a condition. Fortunately, it is possible to cure these fæcal fistulæ, but very skillful treatment is sometimes necessary, and this is not always available. As many of these cases have sooner or later come under my observation, either at St. Mark's Hospital or at one of the military hospitals to which I have been attached, it seems to me that it may be of service to record the experience that has been gained so that it may prove of assistance to others who have difficult cases of this nature to deal with. One fact has been only too obvious — that the right methods of operating upon fæcal fistulæ are not well understood, for the great majority of cases had been previously unsuccessfully operated upon, often several times. Not only had the attempts to close the fistulæ been failures, but in most cases it was obvious that the method adopted had no chance of succeeding and was simply a useless and unnecessary operation. Many of these cases are extraordinarily complex and present quite exceptional difficulties, so that a certain proportion of failures is to be expected, but the number of patients with a history of repeated unsuccessful operations is much larger than it should be, and this can only be due to the fact that many surgeons have failed to realize the difficulties that such cases involve, or to find out the proper methods of dealing with them. As showing the great difficulties which such cases may present the two following are briefly recorded.

E. H., an officer, wounded in the retreat from Mons in 1914, came into hospital with a fæcal fistula over the left ilium. There was a hole the size of a half dollar right through the wing of the left ilium, with considerable comminution of the bone and injury of the sigmoid flexure and parts posterior to the peritoneum as far as the spine. All the fæces escaped through the wound. The wound was of considerable depth and horribly septic. The patient himself was very ill, having been for two and a half days on straw in a cattle truck before being brought over. A few hours after his arrival profuse hæmorrhage from the wound occurred. It was impossible to deal with the bleeding by plugging the wound owing to the fæcal fistula, and immediate operation was decided upon. The abdomen was opened, and the damaged colon, which had a large rent in it, was detached from the inside of the ilium. The damaged part was cut away and the colon stitched up, the abdominal wall being closed with drainage. The wound in the ilium was then plugged and the bleeding controlled. The patient eventually made a good recovery and returned to the army.

A. C., an officer, wounded in France in 1916, came into hospital with two fæcal fistulæ in the mid line of the abdomen. The fistulæ were in the center of a thin scar 2 inches wide, extending from the ensiform cartilage to the pubes. The condition was the result of a severe shell wound with numerous injuries to the intestine, and two previous operations had been performed in France to which he undoubtedly owed his life. The upper fistula connected with the jejunum, and the lower one with the ileum and the bladder (fæces and urine escaping from it). The patient was very ill, and the abdominal wall badly ulcerated from digestive juices. Food given by the mouth came out of the upper fæcal fistula in 15 to 20 minutes. Owing to the bad condition of the patient the operation was performed under spinal anæsthesia. The whole scar was cut out with the fistulæ attached, and when it was freed and lifted up two loops of intestine could be made out passing to the fistulæ. The condition was much complicated by extensive adhesions. The loop of jejunum attached to the upper fistulous opening was first resected and the ends joined up. The lower loop was then similarly treated and, with considerable difficulty, the abdominal wall was closed. The hole in the fundus of the bladder was drained with a large tube brought out above the pubes. The patient made a good recovery and had no further fæcal leakage. The bladder wound healed in a fortnight. The patient was able to return to military duty, though he had rather a weak scar in the abdominal wall over which it was necessary for him to wear a support.

We may classify fæcal fistulæ as follows:

1. Temporary colostomies with a spur, the operation having been performed at the casualty clearing station or a base hospital for wounds of the rectum or colon.

2. Cases where mucous membrane is adherent to the skin. The opening may be quite small, but more frequently is large and accompanied by extensive prolapse of the gut.

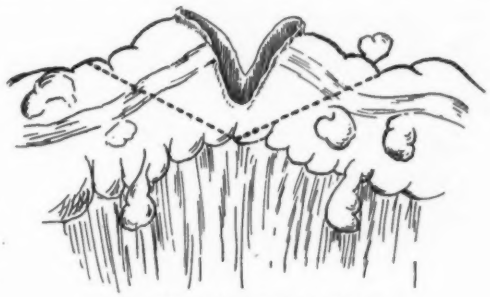
3. Cases in which a fibrous track or sinus connects the gut with the skin opening.

4. Cases where the gut opens into an abscess cavity connecting with the surface.

5. Cases of fæcal fistulæ complicated by compound fractures and hæmorrhage.

It is obvious that considering the great variety and complexity of the cases there can be no one operative technique which is applicable to all, but that frequently some special method will be required to suit the circumstances of the case. Nevertheless, there are certain principles which must always be observed if a good result is to be obtained. Fæcal fistulæ are generally complicated by considerable excoriation of the skin around the opening, and in the case of cæcal or small gut fistulæ this is particularly severe. Before any operation is performed the skin must be brought into as good a condition as possible or there will be little chance of success. For this purpose I administer opium in sufficient doses to cause a considerable degree of constipation and, where possible, the formation of solid stools. After a week or more, if the case is carefully nursed and the skin protected by dressings of lanoline, a very marked improvement will have taken place. Previous to operation the bowel is cleared by enemata and "washouts" administered through the fistula and aperients are not used.

One of the important points in operating is to open the abdominal cavity to one side of, and well away from, the fistulous opening. The exact method of doing this varies, but the principle is the same — to get into the abdominal cavity and then, with the parts well exposed, completely to free the gut and fistula in one piece. The involved parts can then be drawn out of the abdomen and the exact anatomical condition ascertained. It is important to open up the abdominal cavity freely and get a good exposure of the parts involved. As much of the involved portion of the bowel is cut away as is considered necessary so as to leave quite healthy tissues which can be brought together to form the anastomosis or closure. Sometimes this will involve the complete resection of several inches of bowel, but more frequently a large hole will be left in the bowel which only requires careful suture. It is a point of great importance that the blood supply to that part of the bowel wall which it is proposed to suture should be carefully preserved. I am convinced that most of the failures are due to this important factor having been neglected. The bowel should always be so cut that more of the bowel wall is cut away at the free side than at the mesenteric side, even healthy bowel being removed if necessary. The cut edges



Dotted lines show lines of excision.

of the bowel which are going to be joined should form roughly an angle of 45 degrees with the mesenteric border. This makes certain that the stitches joining the ends of the bowel on the mesenteric side do not cut off the blood supply to the joined edges on the free side (see diagram).

Lastly, the hole in the bowel is sewed up, the edges being brought together with catgut sutures passing through all the coats and this line of suture is reinforced with a second catgut suture through the peritoneal coat only. The abdominal wall is closed, and a small drain, preferably of rubber tissue, is inserted down to the point of closure and brought out between two of the stitches. This drain can be removed in 36 hours. It is always advisable to have a drain, as of necessity there must be some infection of the wound by bacillus coli. This infection seldom causes any trouble if a small drain is provided to enable blood effusion to escape, but without such drainage abscess formation is liable to occur. The rubber tissue drain has many advantages over stiff tubes.

As regards after-treatment, my own practice is to insert a rectal tube at the time of operation and to irrigate very gently with water through this twice daily for the first two or three days. No pressure is used, but the water is allowed to flow in and out again to wash the bowel and keep the tube clear. Liquid petroleum is given daily after the operation and small doses of magnesium sulphate each morning, beginning the day after operation. The object of this is to obtain liquid stools daily. Since using these methods I have had no failure to close the fistula, and very few cases in which immediate primary union has not taken place.

The following case will, I think, demonstrate the need for a better understanding of the necessary principles of success in these cases.

M. S., a private, was operated on in January, 1917, for appendicitis, in a military hospital, and as a result of this operation a fæcal fistula formed. He was again operated

on in October, 1917, at another hospital, but without success. He was then transferred to another military hospital where two more operations were performed both of which were unsuccessful, and after one of which he was very ill indeed, with rigors, jaundice, and pelvic phlebitis. He was then transferred to another military hospital and in May, 1918, was operated on again, the result of which was another failure. Two months later he was again unsuccessfully operated upon. Finally, in September, 1918, he came into St. Mark's Hospital. He then had a large cæcal fistula through which everything escaped. The opening was 2 inches long and 1 inch across; there was a considerable prolapse of the cæcum, and the abdominal wall was in a dreadful state with extensive ulceration around the opening. I performed the sixth operation for closure of the opening. This was successful and he is now quite well.

The most difficult cases to deal with are those in which there is a fibrous track between the skin and the opening in the bowel. Such cases are often the result of injury to the pelvic portion of the rectum. It is perfectly useless to attempt to close them by operating upon the skin opening. The only successful method is to open the abdomen well away from the fistula and get at the bowel end of the fistula. This must be cut out and the opening in the bowel closed. The fistula itself can either be cut out, or if extensively involved in adhesions, left to close of itself, which it will soon do if disconnected from the bowel. In the case of fæcal fistulæ discharging into an abscess cavity the abscess must be laid open and freely drained, and the fistula operated on later.

Many of these cases of fæcal fistulæ with a fibrous track between the bowel and the skin surface will heal without operation if the patient is kept constipated so that only solid stools pass the point of leakage, and the fistula itself is left alone; on no account should the fistula be plugged.

Fæcal fistulæ involving the rectum and accompanied by extensive wounds of the sacrum or buttocks are generally treated at the Casualty Clearing Station by establishing a colostomy opening. If this has already been done the colostomy should on no account be closed until the rectal wound has healed up. I have met with cases in which this very obvious precaution has not been observed. If a colostomy has not been done the question of making one should be considered, but if the wounds are granulating satisfactorily in spite of the fæcal discharge, it is not always necessary to do a colostomy. If the wound in the rectum is small and the mucosa can be kept well away from the skin there is a good chance of healing without a temporary colostomy. To avoid pressure in the rectum, which will tend to prevent healing of the wound, a rubber tube should be kept in the anus, or the sphincter divided posteriorly. Rectal openings can always be made to heal provided the mucosa is not allowed to heal to the skin.

A NEW SIGN OF FÆCAL IMPACTION

By DR. RICARDO FINOCHIETTO, Buenos Aires, Argentine

PATHOGNOMONIC signs are very important, but unfortunately they are very rare. In 1915 we noted a new sign of fæcal impaction and as we have not found it in connection with any other abdominal tumor or pathological condition, we are inclined to regard the sign as pathognomonic. Two signs of fæcal impaction have been described, but because we sometimes find misleading cases, a third sign will be useful. The first sign is a depression that the palpating finger leaves if the impaction is a soft one. It is not of common incidence. The second sign is the Gersuny or Klebs symptom that is elicited by pressing upon the tumor then suddenly relieving the pressure. The sign is a feeling as if two wet surfaces were separated at the moment that the pressure is released.

The sign which we are about to describe is the auditory translation of the Gersuny sign. It is elicited as follows: Over the chosen area the funnel-shaped end of a French stethoscope is applied. Over the shell end firmly is applied the observers ear, holding the instrument lightly with the fingers. The abdominal wall is depressed a few (10 to 40) millimeters with the stethoscope, and then the pressure is suddenly released. During the withdrawal of the stethoscope is heard a large moist râle if the sign is positive. Sometimes this is heard not only during the release of pressure but also during its application. Sometimes it is necessary to change frequently the place of the funnel in looking for this sign before it is found. Until the present time we have found the sign positive in every patient with fæcal impaction. These crepitations are found much more easily than the Gersuny or Godet signs. If the crepitations persist after evacuation of the bowels, it indicates that evacuation was not com-

plete. Very often we have been able to find crepitations not only over the fæcal tumor but elsewhere in the abdomen as well, in places where there was no palpable tumor, but where the X-rays showed pathology as in the giant sigmoid, the anatomical site of almost every fæcal impaction. The reason that we get crepitations in some places and in some others we do not is because the impacted fæces are of very different consistency; the half-hardened, very sticky portions that are irregularly scattered throughout an impaction are most likely to give crepitations.

The sign is very useful when, without a previous history of constipation, the tumor is small, hard and slightly movable, and the Gersuny sign is missing. At some place in the abdomen we will find the crepitations of some sticky bit, that is on the way to reach the impacted mass.

The sign is also of use after evacuation of the bowels to enable one to judge as to the completeness of evacuation.

We did not make an exhaustive research of the literature, but we did not find this sign mentioned in the current textbooks.

FOREIGN BODY IN THE URINARY BLADDER

By B. H. CAPLES, M.D., New York
Captain, Medical Corps, U.S.A., U.S. General Hospital No. 14, Fort Oglethorpe, Georgia

IN the literature at hand there are no references to the method of treatment detailed below, and this leads me to believe that a report of the following case will be of interest.

Private J. L., age 21, admitted to Ward X, urological service, December 23, 1918.

His past history was negative, except for urethritis, probably gonorrhœal, in June, 1917. He has had recurrent attacks of urethral discharge since that time.

On December 20, thinking he was going to be examined for discharge from the Army, he inserted a pencil of paraffin in his urethra in order to conceal a slight urethral discharge from which he was suffering at that time. The pencil was made from a candle, consisting largely of paraffin and measured approximately 5 centimeters in length and 7 millimeters in diameter. During the day this passed into the bladder. The following morning his urinations became frequent, painful and bloody. These symptoms increased in severity until he was admitted, two days later, to the urological service.

His present complaint was the passage of bloody urine about every half hour, pain at the end of urination, sense of obstruction, and occasionally inability to pass any urine whatever.

Examination revealed normal external genitals. On cystoscopic examination the paraffin, corresponding in mass, but differing somewhat in shape from the pencil could be seen plainly just within the vesical neck and firmly lodged at its upper margin. *Diagnosis:* Foreign body in bladder.

Treatment. Three attempts, at intervals of several days, were made to remove the paraffin with a cystoscopic rongeur but owing to the location of the mass they were unsuccessful. In the meantime, having secured a candle of the same kind as the one he had used, I cut from it a number of cubes each measuring 1 centimeter, and placed one in each of a series of test tubes. To them were added 5 cubic centimeters of zylene, kerosene, paraffin oil, gasoline and also varying proportions of these solvents. The tubes were then incubated at 37° C. and from time to time a little urine added to each one. The cubes in both the gasoline and zylene were dissolved in 10 hours, in kerosene in 11 hours, in paraffin oil in 36 hours and in a solution of 33⅓ per cent gasoline in paraffin oil in 12 hours. As this latter solution could be held in the mouth for several minutes without irritation and as it was nearly as efficient as the others, which were more or less irritant, I decided to use it. Through a retention catheter 125 cubic centimeters at 110° F. was injected into the bladder. This was easily tolerated and retained comfortably for one and a half hours. After this injection the retention catheter was found to be no longer necessary. Six subsequent injections, each of 125 cubic centimeters and at 110° F. were given. These were retained for intervals varying from 2 to 5 hours. The entire treatment covered a period of three days and the total time of exposure to the solvent was 17 hours. The urine and solvent were collected after each injection and by chilling them the paraffin was precipitated in decreasing amounts down to the fifth specimen. As the sixth and seventh gave no precipitate the injections were discontinued. In the meantime the patient's symptoms abated rapidly and two days after his last injection his condition was normal. One week later on cystoscopic examination the bladder was normal and no trace of paraffin could be found.

The gasoline used in such cases should be of low grade, about 55 degrees, Baume scale (as this volatilizes less rapidly than the higher grades), and may be sterilized by filtration with a Berkefeld filter, in the absence of which it should be filtered through chamois skin that has been thoroughly washed in hot water and soap, lysol solution and distilled water. It should then be exposed, in a sterile glass container, to the action of sunlight for several hours. Sterile paraffin oil is on sale in original packages.

I wish to acknowledge my indebtedness to Sergeant Roy Primm, of the department of pathology, for his assistance.

A METHOD OF TRACHEOTOMY WITHOUT LOSS OF BLOOD[1]

By DONALD GUTHRIE, M.D., F.A.C.S., Sayre, Pennsylvania
Robert Packer Hospital

BLOOD inspired into the trachea during the operation of tracheotomy is a frequent cause of pneumonia and death. An operation which is planned to prevent bleeding and yet does not take any longer to perform in the urgent case than the methods usually employed is, I believe, worthy of consideration and discussion.

Two operations for tracheotomy are used — the high and the low operation. The high operation is performed in the space between the cricoid cartilage and the isthmus of the thyroid gland; the low operation in the space below the isthmus of the thyroid and the sternal notch.

The high operation is the one in favor and advocated by most surgeons. Treves prefers the high operation because the muscles of the neck are distinctly separated, the main vessels of the neck, the inferior thyroid artery or an enlarged thymus are not encountered in this region, the anterior jugular veins are small and have very few transverse branches and the trachea is nearer the surface. Binnie says that should the isthmus of the thyroid be encountered in the high operation it may be loosened from the trachea by making short transverse incisions through the deep fasia and pulled downward. Bryant believed that division of the isthmus in children does not interfere with the future function of the thyroid and advised that the isthmus should be divided whenever it was found in the operative field. The isthmus of the normal thyroid lies over the third and fourth rings of the trachea. This gives a working space of but two rings below the cricoid cartilage if the isthmus is not to be injured in the high operation (Fig. 1).

From observations made at the time of goiter operations and from dissections giving an opportunity to study the anatomical relations of the structures above and below the isthmus of the thyroid gland, I believe that the low operation of tracheotomy, unless there should be enlargement of the thyroid, is the more suitable for all cases, even the struggling child. My reasons for this opinion are the following:

The low operation is the better one to perform as a preliminary operation for laryngotomy, laryngectomy, and for resection of the tongue, because it gives a wider working field at the time of the secondary operation.

For foreign bodies in the trachea, where the services of an expert bronchoscopist cannot be had, it is a better site to open the trachea because the foreign body will usually be found in one of the bronchi.

To refute the statement that the high operation is the one of choice in children I maintain that the isthmus of the thryoid gland cannot be divided without the loss of a large amount of blood and the loss of valuable time in some cases, if this bleeding is to be controlled; also that the pyramidal lobe of the thyroid is encountered much more frequently than is generally supposed. The pyramidal lobe of the thyroid is extremely vascular as is well appreciated by those who operate upon the thyroid gland, and it cannot be separated from the trachea without the loss of a large amount of blood and time.

I have studied the sternohyoid muscles repeatedly during goiter operations to see if the assertion that these muscles were separated in the region between the isthmus of the thyroid and the cricoid cartilage were true. I have never found them to be separated. The sternothyroid muscle is thin and can easily be separated in the low operation. I have also studied the anterior jugular veins and their communicating branches, and apparently there is no difference in the size of these veins in the region of the high operation and the low operation. I have encountered communicating branches often but my observations have led me to believe that they are found more frequently above the isthmus than below it. If the anatomical relations of the superficial and deep veins below the thyroid are appreciated, the trachea can be opened in the low operation with little or no loss of blood in most instances.

The anterior jugular vein extends downward from the chin upon the mylohyoid and sternohyoid muscles emptying into the external jugular or subclavian veins below the origin of the sternomastoid muscle. It anastomoses with adjacent veins and by a large arcus venosus juguli below the thyroid gland (¼ to ½ inches above the sternal notch with the vein from the opposite side). It is this large arcus venosus — or communicating branch between the anterior jugular veins — which must not be injured in the operation of low tracheotomy (Figs. 2 and 3).

Lying deeply in the median region of the neck behind the sternohyoid and sternothyroid mus-

[1] Read before Pennsylvania State Medical Society, Philadelphia, September 25, 1918.

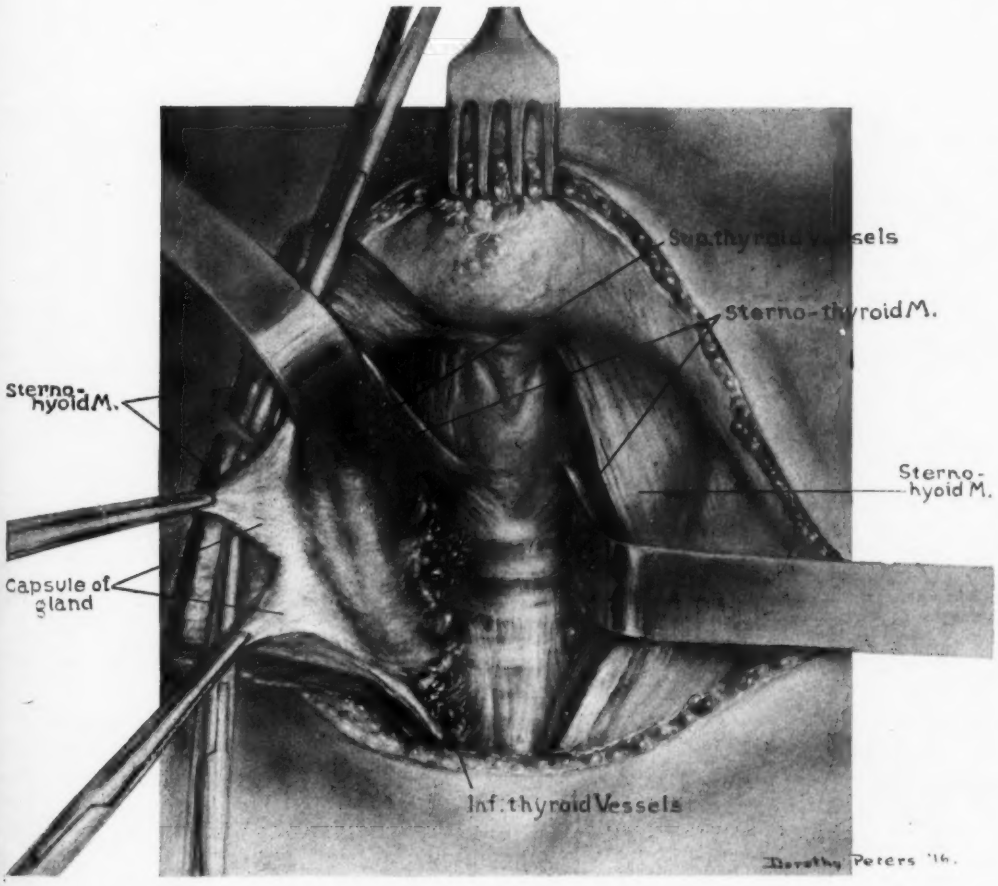


Fig. 1. Anatomical relations of the trachea seen after tracheotomy showing a better working space below the isthmus of the thyroid than above.

cles and at the lower margin of the isthmus of the thyroid gland is an unpaired venous network formed from the inferior thyroid veins, the unpaired thyroid venous plexus (plexus thyroideus impar), which gradually empties into an unpaired vessel, vena thyroidea ima, descending in front of the trachea and emptying into the left innominate vein behind the manubrium of the sternum (Fig. 4).

In addition there is also a pair of lateral inferior thyroid veins, which collect blood from the lower portions of the lateral lobes of the thyroid gland, anastomosing with preceding vessels the right vein opens at the angle of junction of the innominate veins or into the right innominate or into the right internal jugular, or into the right subclavian. The left vein empties into the left innominate. These veins lie laterally to the trachea and are not encountered in low tracheotomy (Fig. 5).

The blood from the lower poles of the thyroid is collected by three unpaired venous branches. The vena thyroidea ima lies in the mid line directly over the trachea. It must be recognized and pulled aside by retractors before the trachea is opened (Fig. 5).

To describe the operation briefly we shall consider three different types of tracheotomy:

1. The preliminary operation in which the patient can be anæsthetized and a careful dissection carried out.

Fig. 2. Dissection showing arcus of external jugular veins just above sternal notch.

Fig. 3. First step in thyroidectomy showing the relation of the arcus venosus juguli.

Fig. 4. Separation of the sternohyoid and sternothyroid muscles, showing relation of inferior thyroid venous plexus and thyroidea ima on trachea.

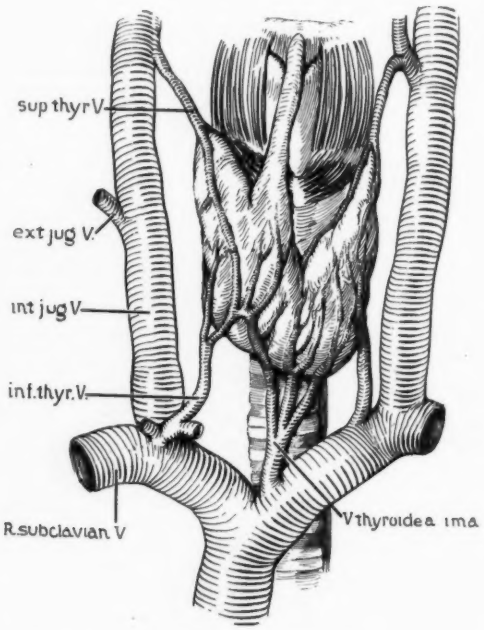


Fig. 5. Diagrammatic drawing to show the relations of the lateral inferior thyroid veins, plexus thyroideus impar, and vena thyroidea ima.

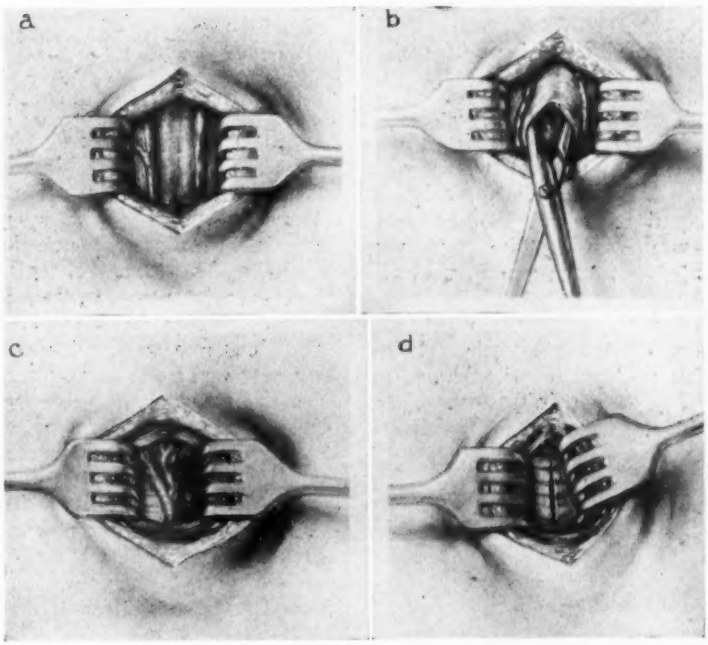


Fig. 6. Steps of the operation of low tracheotomy.

2. In the pulling patient, who needs tracheotomy and not intubation, or in whom intubation has failed to relieve the obstruction. Time can be taken to operate on these patients under local anæsthesia.

3. The extreme case on the point of asphyxiation, who is struggling and fighting for breath, and who must be operated upon without anæsthesia.

In the first and second type little or no blood need be lost if the relation of the veins is appreciated. In the third type, if the thyroid ima can be pulled aside successfully no blood need be lost.

If the patient is a child it is wrapped in a blanket or sheet to control its struggling and placed upon the operating table or on a table in the home. A pad of some sort is put under the shoulders and the head is hung over the end of the table—steadied by an assistant. The operator stands on the right hand side of the table and steadying the skin with the left hand, makes an incision in the mid line of the neck 1½ to 1¾ inches long.

DaCosta gives the distance between the manubrium and cricoid in an adult as 2¾ inches, in a child of ten 2¼ inches, and in a child of six about 2 inches. The incision should not extend down to the sternal notch but must end one-half inch above it to avoid the arcus of the anterior jugular veins. The skin and the superficial fascia are incised, and the wound held open by a pair of catspaw retractors which should not be more than 1 inch in breadth. The parallel branches of the anterior jugular veins escape injury if the incision is made in the mid line of the neck because they lie to either side of it. The sternohyoid and sternothyroid muscles are separated by blunt dissection. If care can be exercised during this step of the operation, the muscles can usually be separated without injury to the thyroid ima beneath. The retractors are reset. The left blade holds aside the skin, the fascia and the two muscles; the right blade holds the skin, fascia, the muscles and the thyroid ima vein. This exposes the trachea. It is incised, the head is straightened, and the tracheotomy tube inserted (Fig. 6).

This method has been employed fourteen times in all types of cases by myself and associates; twelve times in the hospital, twice in the home. We are convinced that it is one of value.

THE ETIOLOGY AND TREATMENT OF CYSTOCELE[1]

By J. CRAIG NEEL, M.D., San Francisco

So much has already been written upon perineal lacerations and their sequelæ that one is inclined to apologize for further communications. However, some observations made during the past year may be of interest to the members of this society.

While uterine prolapse may occur in nulliparous women, extensive anterior vaginal relaxation with prolapse of the bladder is almost invariably due to injuries associated with childbirth.

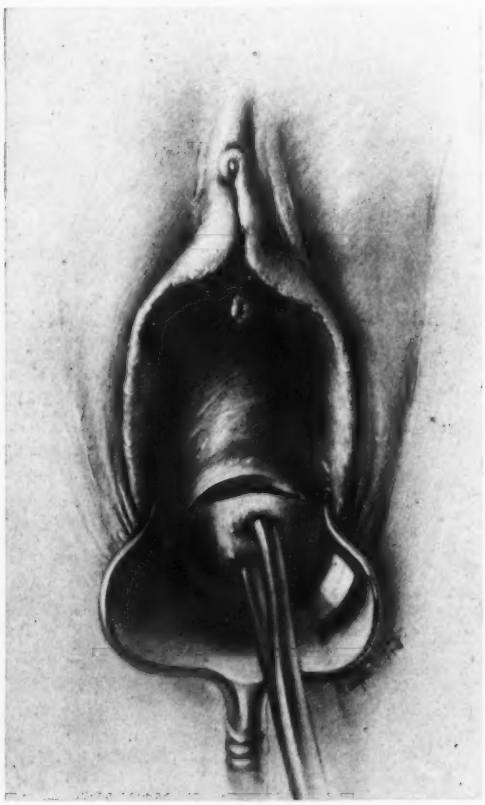


Fig. 1. Transverse incision through the vaginal mucosa and fascia just below the bladder reflection on the cervix.

From a study of the anatomical preparation of prolapse described by Halban and Tandler, Dickinson has noted four planes of cleavage: (1) postpubic, near the symphysis pubes; (2) urethrovaginal septum, just below the urethra; (3) rectovaginal septum, behind the vagina; and (4) anorectal.

This classification is based upon pathological conditions and emphasizes the absurdity of trying to make one operation meet the many forms of prolapse. Cystocele occurs with a displacement of the first or second segment with or without disturbance of the other planes of cleavage.

The pelvic basin is imperfect in its bony boundaries and is completed to a large extent by muscle and fascia. The pelvic fascia is a direct continuation of the abdominal fascia and has its origin at the "white line," the back of the symphysis and the pubic ramus. According to Cunningham, the white line extends between the back of the pubis and the spine of the ischium, and roughly indicates the line of separation of the pelvic cavity from the ischiorectal fossa. It gives origin to fibers of the levator ani muscle, and also to a secondary sheet of fascia, known as the visceral pelvic fascia, which arches downward and inward across the floor of the pelvis to be connected with the pelvic viscera. This membrane is thin and unimportant behind, as it passes forward from the lower sacral vertebræ to the rectum. It is thicker at the sides and front of the pelvis, where it forms a stout membrane, concave upward, continuous mesially with the fibrous coats of the rectum and the bladder and envelopes the prostate gland and seminal vesicals in the male and the cervix and vagina in the female. At the front of the pelvis, this layer extends from the back of the pubis to which it is directly attached to the neck of the bladder and prostate gland in the male and to the neck of the bladder and cervix in the female.

This fascia is found to be quite dense sur-

[1] Read before the California State Medical Society, Coronada, April, 1917. An abstract of this paper was published in the California State Journal, April, 1917, p. 121.

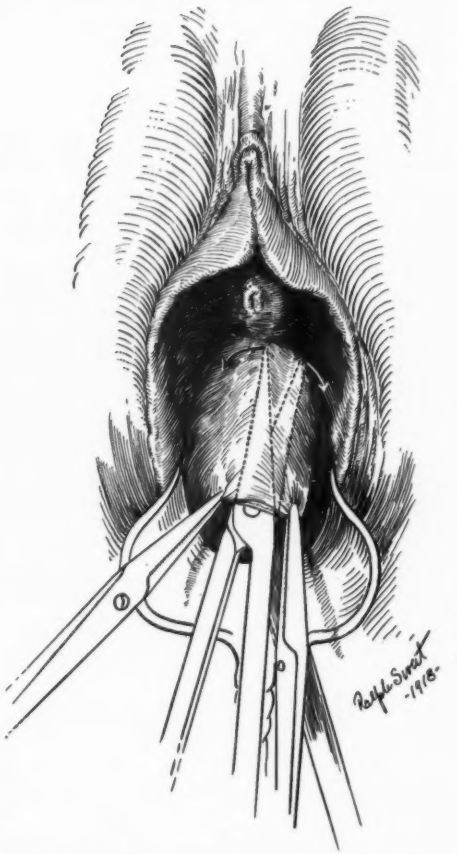


Fig. 2. Drawing showing the method of dissecting the bladder from the anterior vaginal fascia. Traction should be made on clamps and the points of scissors elevated to avoid puncture of the bladder.

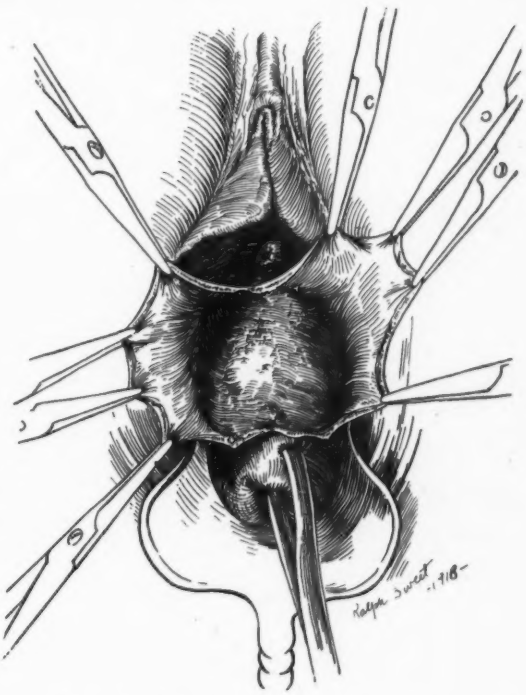


Fig. 3. Median incision of fascia and mucosa exposing the muscle wall of the bladder.

rounding the cervix and prolongations from it, form the cardinal or Mackenrodt and the uterosacral ligaments, the true supporting structures of the cervix.

While the urachus (ligamentum umbilicale medium) and the peritoneal folds limit the lateral movements of the bladder, their attachments do not allow any suspensory function whatever. Therefore, one must conclude that the true support for the bladder is the endopelvic fascia and when this support is weakened sufficiently, a true hernia results.

The importance of having the bladder emptied to allow the head to enter the pelvis has long since been recognized. The neglect of this procedure not only prolongs labor but allows strong pressure to be put upon the anterior vaginal wall and thus, by overstretching the fibers, decreases the efficiency of the fascial diaphragm. Hence the bladder should be kept empty during delivery, and overdistention prevented during the puerperium to allow the pelvic structures to regain their normal tone. Anterior tears and cervical lacerations involving the fascia should be repaired immediately.

The giving way of the pelvic fascia allows the bladder to descend forming what is generally spoken of as a cystocele. Clinically a prolapse of the bladder may occur: (1) alone; (2) with a prolapse of the urethra; (3) with a prolapse of the uterus, partial or complete; (4) with a rectocele; or (5) where all these conditions are present in the same patient. Hence the importance of various operations,

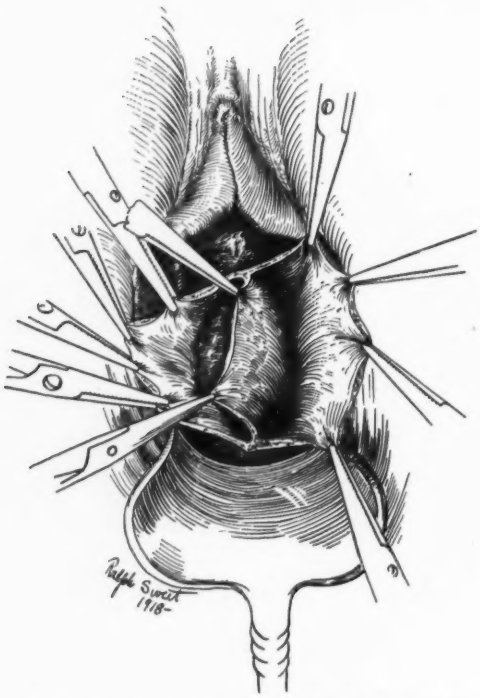


Fig. 4. Drawing showing separation of fascial layer from the mucosa.

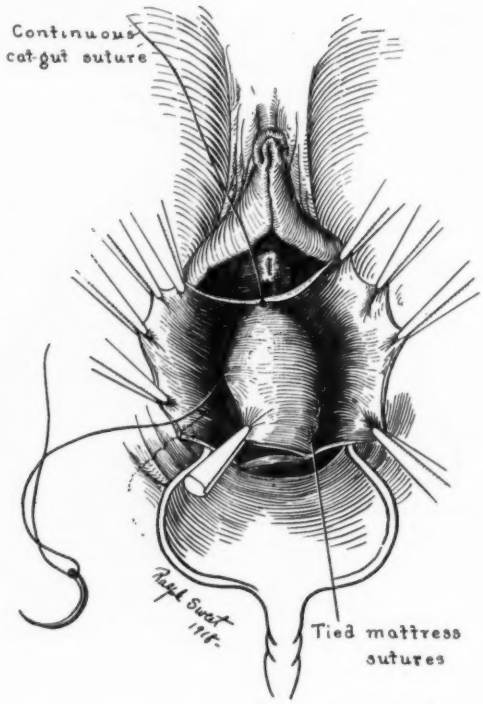


Fig. 5. Drawing showing method of overlapping the fascial flaps.

depending upon the pathologic conditions, can be readily seen. It is the purpose of this paper to present the treatment of a simple cystocele, since the operations so far devised have given very unsatisfactory results. In a subsequent paper I hope to take up the consideration of the treatment of the other conditions.

In the first place it is important to consider a cystocele as a hernia and a cure can only be hoped for when the function of true supporting structures is restored.

TECHNIQUE

The cervix is drawn down and a deep transverse incision is made just below the bladder wall, through the vaginal mucosa and the underlying fascia (Fig. 1). The proximal flap is caught by forceps, care being taken to include the fascia; with a pair of blunt scissors, preferably the Mayo type, the dissection is carried between the muscle wall of the bladder and the fascia to the urethra (Fig. 2); a median incision is then made, the bladder is dissected free of the cervix and the fascia and displaced upward to its normal position (Fig. 3). This section is carried out by a small piece of gauze over the finger, the pressure being applied chiefly over the fascia and edge of bladder. The fascial and mucosal edges are then caught separately by clamps and the separation begun by sharp dissection, care being taken to locate the proper layer in order to preserve the entire fascia; by blunt dissection the separation is carried well up to the pubic bones on either side (Fig. 4). The remaining steps of the operation are identical to those employed in the treatment of hernia. The two flaps of fascia are overlapped by mattress sutures of No. 2 chromic catgut which are placed as close as possible to the pubic bones (Fig. 5). The excess mucosa is then excised

and the cut edges approximated with a running suture of catgut.

This operation was first performed by me in July, 1916. Since that time I have employed it in all cases where a cystocele was present, and there has not been even the slightest tendency toward a recurrence in a single case. It was my privilege recently to see a delivery at term in a patient upon whom I had done this operation one and one half years previously. Labor was not delayed, the bladder did not appear in sight during the entire delivery, and there was no tearing of the anterior vaginal wall.

AN IMPROVED METHOD FOR STERILIZING CATGUT SUTURES

By CASSIUS H. WATSON, B.Sc., M.D., Brooklyn

THE usual commercial methods of sterilizing catgut sutures have always been susceptible of improvement. If absolute sterility of the sutures were the only consideration it would be a simple matter to apply such physical agents as heat or heat plus disinfecting solutions. It must be remembered, however, that catgut easily suffers deterioration, and that methods of sterilization wholly suitable and proper when applied to more stabile material quickly rob catgut of those properties which are essential for their surgical integrity. In addition to sterility, sutures must possess a maximum tensile strength, utmost flexibility, and the desired degree of absorbability. Furthermore, the medium in which the sutures are immersed, as well as the sterilizing process, must be such that the sutures suffer no physical damage during or after sterilization, and come to the surgeon's hands with all these characters preserved to the highest possible degree.

Realizing the faults of the current methods, an attempt has been made to devise a process of sterilization which would not only insure absolute sterility, but which would also cause no impairment to the other properties of the suture material. The only logical way in which sterility can be obtained and maintained throughout the process of preparation is to sterilize the sutures in their ultimate storing fluid after sealing the tubes. The perfection of such a method constituted the problem studied.

The efficiency of all sterilizing methods is dependent to a considerable degree upon the nature of the storing fluid employed. Such substances as chloroform and alcohol, ordinarily used in commercial practice, are unsatisfactory on account of their low boiling point, their hardening action on the gut, and, in the case of chloroform, the tendency to decompose into objectionable products, causing deterioration of the sutures and imparting to them an irritating action. Rogers[1] had recommended toluol as a storing fluid, and inasmuch as a long series of personal tests has confirmed his opinion and thoroughly demonstrated the advantages of this hydrocarbon over chloroform and alcohol, it was decided to employ toluol exclusively in these experiments. The factors to be determined, then, were the degree of heat to be employed and the duration of the exposure of the sutures to this heat. Not only was the effect of the method on the physical properties tested, but careful bacteriological experiments were carried out with the various sizes and kinds of catgut sutures in order to determine the actual killing power of the method upon different types of unusually resistant bacteria. The details of the experiments were as follows:

Five-foot strands of Numbers 00, 2, and 4 plain and 20-day chromic catgut sutures were made into coils and tied to prevent unrolling, then immersed for four hours in heavy, sporulating broth cultures of—

1. Bacillus mesentericus,
2. Bacillus anthracis,
3. Bacillus tetani.

The strands were thus thoroughly and massively infected. The coils were then dehydrated over calcium chloride and suplhuric acid in a vacuum, tubed in the regular way, the tubes filled with toluol and then submitted to a heat of 165° C. for five hours. In carrying out the bacteriological tests the outside of the tube was disinfected by immersing in corrosive sublimate solution. The

[1] Rogers, Allen. Toloul; its advantages over chloroform and alcohol as a storing fluid for surgical catgut. Ann. Surg., 1916, Mar., pp. 313-316.

tubes were then broken, the sutures removed with sterile forceps, washed in 75 cubic centimeters of sterile distilled water in order to remove the toluol, and then placed in tubes containing 75 cubic centimeters sterile nutrient broth. In the case of the sutures infected with tetanus bacilli the strands were planted in freshly boiled 1 per cent nutrient agar containing 0.5 per cent dextrose cooled to 40° C. The tubes were then incubated for two weeks at 37.5° C. and frequently examined for growth. The experiments were controlled by—

1. Transplanting into fresh broth 0.1 cubic centimeter of the broth culture used in infecting the sutures;

2. Planting two sutures of each size of each kind after infection and drying in order to prove that the sutures contained viable organisms immediately before being subjected to the sterilizing process;

3. By inoculating with the respective organisms the broth or agar containing the infected and sterilized strands when no growth appeared after incubation.

This last control was done in order to demonstrate that the nutrient medium employed was capable of growing any of the three organisms which might have survived the sterilizing process and also that not enough toluol had been carried over with the strands to exert any inhibiting action.

Experiment 1. Separate lots of nutrient broth were inoculated with pure cultures of bacillus mesentericus ruber (bacillus vitalis) and bacillus mesentericus vulgatus (bacillus vulgatus) respectively and incubated until a heavy growth was present. The cultures were then placed at room temperature for three weeks in order to favor sporulation. Stained smears showed an abundance of sporulating forms and free spores. Subcultures on agar and in broth showed luxuriant growth. Eighteen five-foot strands of each size of each kind of sutures were immersed in these cultures, then dried, tubed, and sterilized as already described. The bacteriological examination of the sutures yielded the following results:

None of the tubes containing the sutures subjected to the sterilizing process showed any growth. The sutures were all apparently rendered sterile.

Control 1. Heavy growth of bacillus mesentericus.
Control 2. Heavy growth of bacillus mesentericus.
Control 3. Heavy growth of bacillus mesentericus.

Experiment 2. Nutrient broth was inoculated with a pure culture of bacillus anthracis and incubated until a heavy growth was present, then diluted with isotonic salt solution and placed at room temperature in order to favor sporulation. Stained smears showed an abundance of sporulating forms and free spores. The same number of sutures as in Experiment 1 were treated as above described.

Results. None of the tubes containing the sutures subjected to the sterilizing process showed any growth. The sutures were all apparently rendered sterile.

Control 1. Heavy growth of bacillus anthracis.
Control 2. Heavy growth of bacillus anthracis.
Control 3. Heavy growth of bacillus anthracis.

Experiment 3. Freshly sterilized and cooled broth covered with a deep layer of albolene was inoculated with a pure culture of bacillus tetani and allowed to remain in the incubator at 37.5° C. until the heavy sediment showed a preponderance of sporulating forms and free spores. The suture strands were then treated as already described.

Result. None of the sutures subjected to the sterilizing process showed any growth. The sutures were all apparently rendered sterile.

Control 1. Heavy growth of bacillus tetani
Control 2. Heavy growth of bacillus tetani
Control 3. Heavy growth of bacillus tetani with gas formation.

DISCUSSION

In the three experiments described above representative sizes of catgut sutures corresponding to those usually employed in surgical practice were heavily infected with three different species of sporulating bacilli, thus producing a more massive and resistant bacterial infection of the gut than would occur even under the most unfavorable conditions. With toluol as a tubing or storing medium the sutures were subjected to a temperature of 165° C. for five hours after the tubes had been sealed. The sutures were removed from the tubes and tested for the presence of living bacilli by appropriate bacteriologic methods. The fact that none of the sutures, after having undergone this sterilizing process, showed the presence of any viable organisms would seem to prove the complete efficiency of this method of sterilization. Careful physical tests not detailed here showed no change in the tensile strength, flexibility, or absorbability of the sutures. The method of sterilization as described would, therefore, appear to possess marked advantages over the usual methods in that it insures absolute sterility without in any way affecting the desirable physical properties of the suture material.